

PATENT COOPERATION TREATY

PCT

INTERNATIONAL-TYPE SEARCH REPORT

(PCT Article 15.5)

| | | |
|---|---|---|
| National application No. 9900885-6 | Country or Office of filing SE | Applicant's or agent's file reference SEP/3774 SE/C-G FORSBERG |
| Filing date (day/month/year) 12 March 1999 | (Earliest) Priority Date (day/month/year) | |
| Applicant CelsiusTech Electronics AB | | |

| | |
|--|--|
| Date of request for international-type search 12 March 1999 | International-type search request No. SE 99/00342 |
|--|--|

This international-type search report has been prepared by this International Searching Authority and is transmitted to the applicant.

This international-type search report consists of a total of 2 sheets.

☒ It is also accompanied by a copy of each prior art document cited in this report.

1. ☐ Certain claims were found unsearchable (See Box I).
2. ☐ Unity of invention is lacking (See Box II).
3. ☐ The international application contains disclosure of a nucleotide and/or amino acid sequence listing and the international-type search was carried out on the basis of the sequence listing
 - ☐ filed with the international application.
 - ☐ furnished by the applicant separately from the international application,
 - ☐ but not accompanied by a statement to the effect that it did not include matter going beyond the disclosure in the international application as filed.
 - ☐ transcribed by this Authority.



PATENT COOPERATION TREATY

PCT

INTERNATIONAL SEARCH REPORT

(PCT Article 18 and Rules 43 and 44)

| | | |
|--|--|---|
| Applicant's or agent's file reference 3774 PCT | FOR FURTHER ACTION | see Notification of Transmittal of International Search Report (Form PCT/ISA/220) as well as, where applicable, item 5 below. |
| International application No. PCT/SE 00/00470 | International filing date (<i>day/month/year</i>) 9 March 2000 | (Earliest) Priority Date (<i>day/month/year</i>) 12 March 1999 |
| Applicant CelsiusTech Electronics AB et al | | |

This international search report has been prepared by this International Searching Authority and is transmitted to the applicant according to Article 18. A copy is being transmitted to the International Bureau.

This international search report consists of a total of 3 sheets.

☒ It is also accompanied by a copy of each prior art document cited in this report.

1. ☐ Certain claims were found unsearchable (See Box I).
2. ☐ Unity of invention is lacking (See Box II).
3. ☐ The international application contains disclosure of a nucleotide and/or amino acid sequence listing and the international search was carried out on the basis of the sequence listing
 - ☐ filed with the international application.
 - ☐ furnished by the applicant separately from the international application,
 - ☐ but not accompanied by a statement to the effect that it did not include matter going beyond the disclosure in the international application as filed.
 - ☐ transcribed by this Authority.
4. With regard to the title,
 - ☐ the text is approved as submitted by the applicant.
 - ☒ the text has been established by this Authority to read as follows:

Quantum well based two-dimensional detector for IR radiation and camera system with such a detector
5. With regard to the abstract,
 - ☒ the text is approved as submitted by the applicant.
 - ☐ the text has been established, according to Rule 38.2(b), by this Authority as it appears in Box III. The applicant may, within one month from the date of mailing of this international search report, submit comments to this Authority.
6. The figure of the drawings to be published with the abstract is:

Figure No. 3

 - ☒ as suggested by the applicant.
 - ☐ because the applicant failed to suggest a figure.
 - ☐ because this figure better characterizes the invention.

☐ None of the figures.

INTERNATIONAL-TYPE SEARCH REPORT

Search request No.

SE 99/00342

A. CLASSIFICATION OF SUBJECT MATTER

IPC6: H01L 31/0236, H01L 31/09, G01J 5/20, H04N 5/33
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC6: H01L, G01J, H04N

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

SE,DK,FI,NO classes as above

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

| Category* | Citation of document, with indication, where appropriate, of the relevant passages | Relevant to claim No. |
|-----------|--|-----------------------|
| A | EP 0617471 A2 (NIPPON TELGRAPH AND TELEPHONE CO.), 28 September 1994 (28.09.94), column 9, claim 15 -- | 1-10 |
| A | US 5485015 A (KWONG-KIT CHOI), 16 January 1996 (16.01.96), figures 7,8 -- | 1-10 |
| A | US 5539206 A (THOMAS R. SCHIMERT), 23 July 1996 (23.07.96), abstract -- ----- | 1-10 |

☐ Further documents are listed in the continuation of Box C.☒ See patent family annex.

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance: the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance: the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international-type search

16 November 1999

Date of mailing of the international-type search report

1999 -11- 19

Name and mailing address of the ISA/
Swedish Patent Office
Box 5055, S-102 42 STOCKHOLM
Facsimile No. +46 8 666 02 86

Authorized officer

Lars Jakobsson
Telephone No. +46 8 782 25 00

INTERNATIONAL-TYPE SEARCH REPORT

Information on patent family members

02/11/99

Search request No.

SE 99/00342

| | | | | | | | |
|----|---------|----|----------|----|---------|---|----------|
| EP | 0617471 | A2 | 28/09/94 | JP | 7231144 | A | 29/08/95 |
| | | | | US | 5585957 | A | 17/12/96 |
| | | | | US | 5689358 | A | 18/11/97 |

| | | | | | | | |
|----|---------|---|----------|------|--|--|--|
| US | 5485015 | A | 16/01/96 | NONE | | | |
|----|---------|---|----------|------|--|--|--|

| | | | | | | | |
|----|---------|---|----------|----|----------|---|----------|
| US | 5539206 | A | 23/07/96 | CA | 2220834 | A | 24/10/96 |
| | | | | EP | 0824762 | A | 25/02/98 |
| | | | | JP | 11504763 | T | 27/04/99 |
| | | | | NO | 974814 | A | 17/10/97 |
| | | | | WO | 9633515 | A | 24/10/96 |

INTERNATIONAL SEARCH REPORT

International application No.

PCT/SE 00/00470

A. CLASSIFICATION OF SUBJECT MATTER

IPC7: H01L 31/0236, H01L 31/09, G01J 5/20, H04N 5/33

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC7: H01L, G01J, H04N

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

SE,DK,FI,NO classes as above

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

| Category* | Citation of document, with indication, where appropriate, of the relevant passages | Relevant to claim No. |
|-----------|--|-----------------------|
| A | EP 0617471 A2 (NIPPON TELEGRAPH AND TELEPHONE CO.), 28 Sept 1994 (28.09.94), column 9, claim 15 -- | 1-10 |
| A | US 5485015 A (KWONG-KIT CHOI), 16 January 1996 (16.01.96), figures 7,8 -- | 1-10 |
| A | US 5539206 A (THOMAS R. SCHIMERT), 23 July 1996 (23.07.96), abstract -- | 1-10 |

☒ Further documents are listed in the continuation of Box C.☒ See patent family annex.

* Special categories of cited documents:

- "A" document defining the general state of the art which is not considered to be of particular relevance
- "E" earlier document but published on or after the international filing date
- "I" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
- "O" document referring to an oral disclosure, use, exhibition or other means
- "P" document published prior to the international filing date but later than the priority date claimed

"I" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance: the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance: the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search

6 July 2000

Date of mailing of the international search report

14 -07- 2000

Name and mailing address of the ISA/

Swedish Patent Office
Box 5055, S-102 42 STOCKHOLM
Facsimile No. +46 8 666 02 86

Authorized officer

STURE ELNÄS/EE

Telephone No. +46 8 782 25 00

INTERNATIONAL SEARCH REPORT

International application No.

PCT/SE 00/00470

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

| Category* | Citation of document, with indication, where appropriate, of the relevant passages | Relevant to claim No. |
|-----------|--|-----------------------|
| A | <p>IEEE ELECTRON DEVICE LETTERS, Volume 16, No 2, February 1995, K. L. Tsai et al, "Two-Dimensional Bi-Periodic Grating Coupled One- and Two-Color Quantum Well Infrared Photodetectors", column 2, line 7, figure 1</p> <p>-- -----</p> | 1-10 |

INTERNATIONAL SEARCH REPORT
Information on patent family members

02/12/99

International application No.

PCT/SE 00/00470

| Patent document cited in search report | Publication date | Patent family member(s) | Publication date |
|---|---------------------|--|--|
| EP 0617471 A2 | 28/09/94 | JP 7231144 A US 5585957 A US 5689358 A | 29/08/95 17/12/96 18/11/97 |
| US 5485015 A | 16/01/96 | NONE | |
| US 5539206 A | 23/07/96 | CA 2220834 A EP 0824762 A JP 11504763 T NO 974814 A WO 9633515 A | 24/10/96 25/02/98 27/04/99 17/10/97 24/10/96 |

P/ NT COOPERATION TREAT

PCT

NOTIFICATION OF ELECTION

(PCT Rule 61.2)

From the INTERNATIONAL BUREAU

To:

Commissioner
 US Department of Commerce
 United States Patent and Trademark
 Office, PCT
 2011 South Clark Place Room
 CP2/5C24
 Arlington, VA 22202
 ETATS-UNIS D'AMERIQUE
 in its capacity as elected Office

| | |
|--|--|
| Date of mailing (day/month/year) 01 November 2000 (01.11.00) | |
| International application No. PCT/SE00/00470 | Applicant's or agent's file reference 3774 PCT |
| International filing date (day/month/year) 09 March 2000 (09.03.00) | Priority date (day/month/year) 12 March 1999 (12.03.99) |
| Applicant LINDAU, Sten | |

1. The designated Office is hereby notified of its election made:

☒ in the demand filed with the International Preliminary Examining Authority on:

06 October 2000 (06.10.00)

☐ in a notice effecting later election filed with the International Bureau on:2. The election ☒ was☐ was not

made before the expiration of 19 months from the priority date or, where Rule 32 applies, within the time limit under Rule 32.2(b).

The International Bureau of WIPO
 34, chemin des Colombettes
 1211 Geneva 20, Switzerland

Facsimile No.: (41-22) 740.14.35

Authorized officer

Manu Berrod

Telephone No.: (41-22) 338.83.38

PATENT COOPERATION TREATY

3774 PCT

From the
INTERNATIONAL PRELIMINARY EXAMINING AUTHORITY

PCT

To:

Bofors Suport AB
Patent and Trademarks
691 80 Karlskoga

2001-03-28

NOTIFICATION OF TRANSMITTAL OF INTERNATIONAL PRELIMINARY EXAMINATION REPORT

(PCT Rule 71.1)

| | |
|-------------------------------------|------------|
| Date of mailing (day/month/year) | 25-03-2001 |
|-------------------------------------|------------|

Applicant's or agent's file reference

3774 PCT

IMPORTANT NOTIFICATION

International application No.

PCT/SE00/00470

International filing date (day/month/year)

09-03-2000

Priority date (day/month/year)

12-03-1999

Applicant

CelsiusTech Electronics AB
et al

1. The applicant is hereby notified that this International Preliminary Examining Authority transmits herewith the international preliminary examination report and its annexes, if any, established on the international application.
2. A copy of the report and its annexes, if any, is being transmitted to the International Bureau for communication to all the elected Offices.
3. Where required by any of the elected Offices, the International Bureau will prepare an English translation of the report (but not of any annexes) and will transmit such translation to those Offices.
4. **REMINDER**

The applicant must enter the national phase before each elected Office by performing certain acts (filing translations and paying national fees) within 30 months from the priority date (or later in some Offices) (Article 39(1)) (see also the reminder sent by the International Bureau with Form PCT/IB/301).

where a translation of the international application must be furnished to an elected Office, that translation must contain a translation of any annexes to the international preliminary examination report. It is the applicant's responsibility to prepare and furnish such translation directly to each elected Office concerned.

For further details on the applicable time limits and requirements of the elected Offices, see Volume II of the PCT Applicant's Guide.

Name and mailing address of the IPEA/

Patent- och registreringsverket
Box 5055
S-102 42 STOCKHOLM
Facsimile No. 08-667 72 88

Telex
17978
PATOREG-S

Authorized officer

Christa Vell

Telephone No. 08-782 25 00

PATENT COOPERATION TREATY

PCT

INTERNATIONAL PRELIMINARY EXAMINATION REPORT

(PCT Article 36 and Rule 70)

| | | | |
|--|---|---|---|
| Applicant's or agent's file reference 3774 PCT | FOR FURTHER ACTION | | See Notification of Transmittal of International Preliminary Examination Report (Form PCT/IPEA/416) |
| International application No. PCT/SE00/00470 | International filing date (day/month/year) 09.03.2000 | Priority date (day/month/year) 12.03.1999 | |
| International Patent Classification (IPC) or national classification and IPC ₇ H01L 31/0236, H01L 31/09, G01J 5/20, H04N 5/33 | | | |
| Applicant CelsiusTech Electronics AB et al | | | |

1. This international preliminary examination report has been prepared by this International Preliminary Examining Authority and is transmitted to the applicant according to Article 36.
2. This REPORT consists of a total of 4 sheets, including this cover sheet.

☐ This report is also accompanied by ANNEXES, i.e., sheets of the description, claims and/or drawings which have been amended and are the basis for this report and/or sheets containing rectifications made before this Authority (see Rule 70.16 and Section 607 of the Administrative Instructions under the PCT).

These annexes consist of a total of _____ sheets.

3. This report contains indications relating to the following items:

- I ☒ Basis of the report
- II ☐ Priority
- III ☐ Non-establishment of opinion with regard to novelty, inventive step and industrial applicability
- IV ☐ Lack of unity of invention
- V ☒ Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability, citations and explanations supporting such statement
- VI ☐ Certain documents cited
- VII ☒ Certain defects in the international application
- VIII ☐ Certain observations on the international application

| | |
|--|---|
| Date of submission of the demand 06.10.2000 | Date of completion of this report 15.02.2001 |
| Name and mailing address of the IPEA/SE Patent- och registreringsverket Box 5055 S-102 42 STOCKHOLM Facsimile No. 08-667 72 88 | Authorized officer Sture Elnäs /OGU Telephone No. 08-782 25 00 |

INTERNATIONAL PRELIMINARY EXAMINATION REPORT

International application No.

PCT/SE00/00470

I. Basis of the report

1. With regard to the elements of the international application:*

- ☒ the international application as originally filed
- ☐ the description:
pages _____, as originally filed
pages _____, filed with the demand
pages _____, filed with the letter of _____
- ☐ the claims:
pages _____, as originally filed
pages _____, as amended (together with any statement) under article 19
pages _____, filed with the demand
pages _____, filed with the letter of _____
- ☐ the drawings:
pages _____, as originally filed
pages _____, filed with the demand
pages _____, filed with the letter of _____
- ☐ the sequence listing part of the description:
pages _____, as originally filed
pages _____, filed with the demand
pages _____, filed with the letter of _____

2. With regard to the language, all the elements marked above were available or furnished to this Authority in the language in which the international application was filed, unless otherwise indicated under this item.

These elements were available or furnished to this Authority in the following language English which is:

- ☐ the language of a translation furnished for the purposes of international search (under Rule 23.1(b)).
- ☒ the language of publication of the international application (under Rule 48.3(b)).
- ☐ the language of the translation furnished for the purposes of international preliminary examination (under Rules 55.2 and/or 55.3).

3. With regard to any nucleotide and/or amino acid sequence disclosed in the international application, the international preliminary examination was carried out on the basis of the sequence listing:

- ☐ contained in the international application in written form.
- ☐ filed together with the international application in computer readable form.
- ☐ furnished subsequently to this Authority in written form.
- ☐ furnished subsequently to this Authority in computer readable form.
- ☐ The statement that the subsequently furnished written sequence listing does not go beyond the disclosure in the international application as filed has been furnished.
- ☐ The statement that the information recorded in computer readable form is identical to the written sequence listing has been furnished.

4. ☐ The amendments have resulted in the cancellation of:

- ☐ the description, pages _____
- ☐ the claims, Nos. _____
- ☐ the drawings, sheet/fig _____

5. ☐ This report has been established as if (some of) the amendments had not been made, since they have been considered to go beyond the disclosure as filed, as indicated in the Supplemental Box (Rule 70.2 (c)).**

* Replacement sheets which have been furnished to the receiving Office in response to an invitation under Article 14 are referred to in this report as "originally filed" and are annexed to this report since they do not contain amendments (Rules 70.16 and 70.17).

** Any replacement sheet containing such amendments must be referred to under item I and annexed to this report.

INTERNATIONAL PRELIMINARY EXAMINATION REPORT

International application No.

PCT/SE00/00470

V. Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

1. Statement

| | | | |
|-------------------------------|--------|-------------|-----|
| Novelty (N) | Claims | <u>1-10</u> | YES |
| | Claims | | NO |
| Inventive step (IS) | Claims | <u>1-10</u> | YES |
| | Claims | | NO |
| Industrial applicability (IA) | Claims | <u>1-10</u> | YES |
| | Claims | | NO |

2. Citations and explanations (Rule 70.7)

The claimed invention relates to a quantum well based two-dimensional detector for infrared radiation and a camera system with such a detector. The invention is intended to solve the problem of the narrow angle where the detector is sensitive and a poor sensitivity for points at the edge of the detector.

The solution according to the invention is to introduce a grating arrangement with a grating interval that varies or changes from the central part of the detector towards the outer parts.

The documents cited in the International Search Report are:

EP 0617471

US 5485015

US 5539206

IEEE ELECTRON DEVICE LETTERS, Volume 16, No2, February 1995, K.L. Tsai et al, "Two-Dimensional Bi-Periodic Grating Coupled One- and Two-Color Quantum Well Infrared Photodetectors"

Cited documents describe quantum well detectors for infrared detection. Among cited documents, the last is closest to describe the invention. In this document is disclosed a detector having different grating interval in two directions.

However, none of the documents describe a grating system with varying intervals of the grating period.

Accordingly, the claimed invention fulfil the requirements of novelty (N), inventive step (IS) and industrial applicability (IA).

INTERNATIONAL PRELIMINARY EXAMINATION REPORT

International application No.

PCT/SE00/00470

VII. Certain defects in the international application

The following defects in the form or contents of the international application have been noted:

In the claims and in the abstract, parentheses for the reference signs are missing.

PCT

REQUEST

The undersigned requests that the present international application be processed according to the Patent Cooperation Treaty.

For receiving Office use only

International Application No.

International Filing Date

Name of receiving Office and "PCT International Application"

Applicant's or agent's file reference
(if desired) (12 characters maximum)

3774 PCT

Box No. I TITLE OF INVENTION

Meddelas senare

Box No. II APPLICANT

Name and address: (Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country. The country of the address indicated in this Box is the applicant's State (that is, country) of residence if no State of residence is indicated below.)

CelsiusTech Electronics AB
S-175 88 JÄRFÄLLA
Sweden

☐ This person is also inventor.

Telephone No.

Facsimile No.

Teleprinter No.

State (that is, country) of nationality:

SE

State (that is, country) of residence:

SE

This person is applicant
for the purposes of:

☐ all designated
States

☒ all designated States except
the United States of America

☐ the United States
of America only

☐ the States indicated in
the Supplemental Box

Box No. III FURTHER APPLICANT(S) AND/OR (FURTHER) INVENTOR(S)

Name and address: (Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country. The country of the address indicated in this Box is the applicant's State (that is, country) of residence if no State of residence is indicated below.)

Lindau, Sten
Libbyvägen 56
S-187 62 TÄBY
Sweden

This person is:

☐ applicant only

☒ applicant and inventor

☐ inventor only (If this check-box
is marked, do not fill in below.)

State (that is, country) of nationality:

SE

State (that is, country) of residence:

SE

This person is applicant
for the purposes of:

☐ all designated
States

☐ all designated States except
the United States of America

☒ the United States
of America only

☐ the States indicated in
the Supplemental Box

☐ Further applicants and/or (further) inventors are indicated on a continuation sheet.

Box No. IV AGENT OR COMMON REPRESENTATIVE; OR ADDRESS FOR CORRESPONDENCE

The person identified below is hereby/has been appointed to act on behalf
of the applicant(s) before the competent International Authorities as:

☒ agent

☐ common representative

Name and address: (Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country.)

Forsberg, Carl-Göran
CelsiusTech
S-175 88 JÄRFÄLLA
Sweden

Telephone No.
+46 8 58085475

Facsimile No.
+46 586 85742

Teleprinter No.

☐ Address for correspondence: Mark this check-box where no agent or common representative is/has been appointed and the space above is used instead to indicate a special address to which correspondence should be sent.

Box No.V DESIGNATION OF STATES

The following designations are hereby made under Rule 4.9(a) (mark the applicable check-boxes; at least one must be marked):

Regional Patent

- ☒ **AP ARIPO Patent:** GH Ghana, GM Gambia, KE Kenya, LS Lesotho, MW Malawi, SD Sudan, SL Sierra Leone, SZ Swaziland, UG Uganda, ZW Zimbabwe, and any other State which is a Contracting State of the Harare Protocol and of the PCT
- ☒ **EA Eurasian Patent:** AM Armenia, AZ Azerbaijan, BY Belarus, KG Kyrgyzstan, KZ Kazakhstan, MD Republic of Moldova, RU Russian Federation, TJ Tajikistan, TM Turkmenistan, and any other State which is a Contracting State of the Eurasian Patent Convention and of the PCT
- ☒ **EP European Patent:** AT Austria, BE Belgium, CH and LI Switzerland and Liechtenstein, CY Cyprus, DE Germany, DK Denmark, ES Spain, FI Finland, FR France, GB United Kingdom, GR Greece, IE Ireland, IT Italy, LU Luxembourg, MC Monaco, NL Netherlands, PT Portugal, SE Sweden, and any other State which is a Contracting State of the European Patent Convention and of the PCT
- ☒ **OA OAPI Patent:** BF Burkina Faso, BJ Benin, CF Central African Republic, CG Congo, CI Côte d'Ivoire, CM Cameroon, GA Gabon, GN Guinea, GW Guinea-Bissau, ML Mali, MR Mauritania, NE Niger, SN Senegal, TD Chad, TG Togo, and any other State which is a member State of OAPI and a Contracting State of the PCT (if other kind of protection or treatment desired, specify on dotted line)

National Patent (if other kind of protection or treatment desired, specify on dotted line):

- | | |
|--|--|
| <input checked="" type="checkbox"/> AE United Arab Emirates | <input checked="" type="checkbox"/> LR Liberia |
| <input checked="" type="checkbox"/> AL Albania | <input checked="" type="checkbox"/> LS Lesotho |
| <input checked="" type="checkbox"/> AM Armenia | <input checked="" type="checkbox"/> LT Lithuania |
| <input checked="" type="checkbox"/> AT Austria | <input checked="" type="checkbox"/> LU Luxembourg |
| <input checked="" type="checkbox"/> AU Australia | <input checked="" type="checkbox"/> LV Latvia |
| <input checked="" type="checkbox"/> AZ Azerbaijan | <input checked="" type="checkbox"/> MD Republic of Moldova |
| <input checked="" type="checkbox"/> BA Bosnia and Herzegovina | <input checked="" type="checkbox"/> MG Madagascar |
| <input checked="" type="checkbox"/> BB Barbados | <input checked="" type="checkbox"/> MK The former Yugoslav Republic of Macedonia |
| <input checked="" type="checkbox"/> BG Bulgaria | |
| <input checked="" type="checkbox"/> BR Brazil | <input checked="" type="checkbox"/> MN Mongolia |
| <input checked="" type="checkbox"/> BY Belarus | <input checked="" type="checkbox"/> MW Malawi |
| <input checked="" type="checkbox"/> CA Canada | <input checked="" type="checkbox"/> MX Mexico |
| <input checked="" type="checkbox"/> CH and LI Switzerland and Liechtenstein | <input checked="" type="checkbox"/> NO Norway |
| <input checked="" type="checkbox"/> CN China | <input checked="" type="checkbox"/> NZ New Zealand |
| <input checked="" type="checkbox"/> CU Cuba | <input checked="" type="checkbox"/> PL Poland |
| <input checked="" type="checkbox"/> CZ Czech Republic | <input checked="" type="checkbox"/> PT Portugal |
| <input checked="" type="checkbox"/> DE Germany | <input checked="" type="checkbox"/> RO Romania |
| <input checked="" type="checkbox"/> DK Denmark | <input checked="" type="checkbox"/> RU Russian Federation |
| <input checked="" type="checkbox"/> EE Estonia | <input checked="" type="checkbox"/> SD Sudan |
| <input checked="" type="checkbox"/> ES Spain | <input checked="" type="checkbox"/> SE Sweden |
| <input checked="" type="checkbox"/> FI Finland | <input checked="" type="checkbox"/> SG Singapore |
| <input checked="" type="checkbox"/> GB United Kingdom | <input checked="" type="checkbox"/> SI Slovenia |
| <input checked="" type="checkbox"/> GD Grenada | <input checked="" type="checkbox"/> SK Slovakia |
| <input checked="" type="checkbox"/> GE Georgia | <input checked="" type="checkbox"/> SL Sierra Leone |
| <input checked="" type="checkbox"/> GH Ghana | <input checked="" type="checkbox"/> TJ Tajikistan |
| <input checked="" type="checkbox"/> GM Gambia | <input checked="" type="checkbox"/> TM Turkmenistan |
| <input checked="" type="checkbox"/> HR Croatia | <input checked="" type="checkbox"/> TR Turkey |
| <input checked="" type="checkbox"/> HU Hungary | <input checked="" type="checkbox"/> TT Trinidad and Tobago |
| <input checked="" type="checkbox"/> ID Indonesia | <input checked="" type="checkbox"/> UA Ukraine |
| <input checked="" type="checkbox"/> IL Israel | <input checked="" type="checkbox"/> UG Uganda |
| <input checked="" type="checkbox"/> IN India | <input checked="" type="checkbox"/> US United States of America |
| <input checked="" type="checkbox"/> IS Iceland | |
| <input checked="" type="checkbox"/> JP Japan | <input checked="" type="checkbox"/> UZ Uzbekistan |
| <input checked="" type="checkbox"/> KE Kenya | <input checked="" type="checkbox"/> VN Viet Nam |
| <input checked="" type="checkbox"/> KG Kyrgyzstan | <input checked="" type="checkbox"/> YU Yugoslavia |
| <input checked="" type="checkbox"/> KP Democratic People's Republic of Korea | <input checked="" type="checkbox"/> ZA South Africa |
| | <input checked="" type="checkbox"/> ZW Zimbabwe |
| <input checked="" type="checkbox"/> KR Republic of Korea | Check-boxes reserved for designating States which have become party to the PCT after issuance of this sheet: |
| <input checked="" type="checkbox"/> KZ Kazakhstan | <input type="checkbox"/> |
| <input checked="" type="checkbox"/> LC Saint Lucia | <input type="checkbox"/> |
| <input checked="" type="checkbox"/> LK Sri Lanka | |

Precautionary Designation Statement: In addition to the designations made above, the applicant also makes under Rule 4.9(b) all other designations which would be permitted under the PCT except any designation(s) indicated in the Supplemental Box as being excluded from the scope of this statement. The applicant declares that those additional designations are subject to confirmation and that any designation which is not confirmed before the expiration of 15 months from the priority date is to be regarded as withdrawn by the applicant at the expiration of that time limit. (Confirmation of a designation consists of the filing of a notice specifying that designation and the payment of the fee. Confirmation must reach the receiving Office within the 15-month time limit.)

| | | | | |
|---|----------------------------------|---|---|--|
| Box No. VI PRIORITY CLAIM | | <input type="checkbox"/> Further priority claims are indicated in the Supplemental Box. | | |
| Filing date of earlier application (day/month/year) | Number of earlier application | Where earlier application is: | | |
| | | national application: country | regional application:* regional Office | international application: receiving Office |
| item (1) 12.3.1999 | 9900885-6 | SE | | SE |
| item (2) | | | | |
| item (3) | | | | |

☒ The receiving Office is requested to prepare and transmit to the International Bureau a certified copy of the earlier application(s) (only if the earlier application was filed with the Office which for the purposes of the present international application is the receiving Office) identified above as item(s): (1)

* Where the earlier application is an ARIPO application, it is mandatory to indicate in the Supplemental Box at least one country party to the Paris Convention for the Protection of Industrial Property for which that earlier application was filed (Rule 4.10(b)(ii)). See Supplemental Box.

Box No. VII INTERNATIONAL SEARCHING AUTHORITY

| | | | |
|--|--|--------|------------------------------|
| Choice of International Searching Authority (ISA) (if two or more International Searching Authorities are competent to carry out the international search, indicate the Authority chosen; the two-letter code may be used): | Request to use results of earlier search; reference to that search (if an earlier search has been carried out by or requested from the International Searching Authority): | | |
| ISA / | Date (day/month/year) | Number | Country (or regional Office) |

Box No. VIII CHECK LIST; LANGUAGE OF FILING

| | |
|---|--|
| This international application contains the following number of sheets: | This international application is accompanied by the item(s) marked below: |
| request : 3 | 1. <input checked="" type="checkbox"/> fee calculation sheet |
| description (excluding sequence listing part) : 8 | 2. <input type="checkbox"/> separate signed power of attorney |
| claims : 3 | 3. <input checked="" type="checkbox"/> copy of general power of attorney; reference number, if any: |
| abstract : 1 | 4. <input type="checkbox"/> statement explaining lack of signature |
| drawings : 4 | 5. <input type="checkbox"/> priority document(s) identified in Box No. VI as item(s): |
| sequence listing part of description : 19 | 6. <input type="checkbox"/> translation of international application into (language): |
| Total number of sheets : 19 | 7. <input type="checkbox"/> separate indications concerning deposited microorganism or other biological material |
| Figure of the drawings which should accompany the abstract: | 8. <input type="checkbox"/> nucleotide and/or amino acid sequence listing in computer readable form |
| Language of filing of the international application: English | 9. <input type="checkbox"/> other (specify): |

Box No. IX SIGNATURE OF APPLICANT OR AGENT

Next to each signature, indicate the name of the person signing and the capacity in which the person signs (if such capacity is not obvious from reading the request).


/Carl-Göran Forsberg/

| | | |
|---|--|--|
| For receiving Office use only | | 2. Drawings: <input type="checkbox"/> received: <input type="checkbox"/> not received: |
| 1. Date of actual receipt of the purported international application: | | |
| 3. Corrected date of actual receipt due to later but timely received papers or drawings completing the purported international application: | - | |
| 4. Date of timely receipt of the required corrections under PCT Article 11(2): | | |
| 5. International Searching Authority (if two or more are competent): ISA / | 6. <input type="checkbox"/> Transmittal of search copy delayed until search fee is paid. | |

| |
|---|
| For International Bureau use only |
| Date of receipt of the record copy by the International Bureau: |
| Form PCT/RO/101 (last sheet) (July 1998: reprint July 1999) |

This sheet is not part of and does not count as a sheet of the international application.

PCT

FEE CALCULATION SHEET Annex to the Request

For receiving Office use only

International application No.

Date stamp of the receiving Office

Applicant's or agent's
file reference

Applicant

CALCULATION OF PRESCRIBED FEES

1. TRANSMITTAL FEE 1000 T

2. SEARCH FEE 8510 S

International search to be carried out by _____
(If two or more International Searching Authorities are competent in relation to the international application, indicate the name of the Authority which is chosen to carry out the international search.)

3. INTERNATIONAL FEE

Basic Fee

The international application contains _____ sheets.

first 30 sheets 3540 b1

_____ x _____ = _____ b2

remaining sheets additional amount

Add amounts entered at b1 and b2 and enter total at B 3540 B

Designation Fees

The international application contains _____ designations.

8 x 760 = 6080 D

number of designation fees payable (maximum 10) amount of designation fee

Add amounts entered at B and D and enter total at I 9620 I

(Applicants from certain States are entitled to a reduction of 75% of the international fee. Where the applicant is (or all applicants are) so entitled, the total to be entered at I is 25% of the sum of the amounts entered at B and D.)

4. FEE FOR PRIORITY DOCUMENT (if applicable) P

5. TOTAL FEES PAYABLE 19130

Add amounts entered at T, S, I and P, and enter total in the TOTAL box

TOTAL

☐ The designation fees are not paid at this time.

MODE OF PAYMENT

☐ authorization to charge
deposit account (see below)

☐ cheque

☐ postal money order

☐ bank draft

☐ cash

☐ revenue stamps

☐ coupons

☐ other (specify):

DEPOSIT ACCOUNT AUTHORIZATION (this mode of payment may not be available at all receiving Offices)

The RO/ _____ ☐ is hereby authorized to charge the total fees indicated above to my deposit account.

☐ (this check-box may be marked only if the conditions for deposit accounts of the receiving Office so permit) is hereby authorized to charge any deficiency or credit any overpayment in the total fees indicated above to my deposit account.

☐ is hereby authorized to charge the fee for preparation and transmittal of the priority document to the International Bureau of WIPO to my deposit account.

Deposit Account No.

Date (day/month/year)

Signature

PATENT COOPERATION TREATY

3774 PCT

From the INTERNATIONAL SEARCHING AUTHORITY

PCT

To:

Bofors Suport AB
Patent and Trademarks
691 80 Karlskoga

NOTIFICATION OF TRANSMITTAL OF THE INTERNATIONAL SEARCH REPORT OR THE DECLARATION

(PCT Rule 44.1)

| | |
|--|---|
| Applicant's or agent's file reference 3774 PCT | Date of mailing (day/month/year) 14 -07- 2000 |
| International application No. PCT/SE00/00470 | International filing date (day/month/year) 09-03-2000 |
| Applicant CelsiusTech Electronics AB et al | |

1. ☒ The applicant is hereby notified that the international search report has been established and is transmitted herewith.
 Filing of amendments and statement under Article 19:
 The applicant is entitled, if he so wishes, to amend the claims of the international application (see Rule 46):
 When? The time limit for filing such amendments is normally 2 months from the date of transmittal of the international search report; however, for more details, see the notes on the accompanying sheet.
 Where? To the International Bureau of WIPO
 34, chemin des Colombettes
 1211 Geneva 20, Switzerland
 Facsimile No.: (41-22) 740.14.35
 For more detailed instructions, see notes on the accompanying sheet.
2. ☐ The applicant is hereby notified that no international search report will be established and that the declaration under Article 17(2)(a) to that effect is transmitted herewith.
3. ☐ With regard to the protest against payment of (an) additional fee(s) under Rule 40.2, the applicant is notified that:
 - ☐ the protest together with the decision thereon has been transmitted to the International Bureau together with the applicant's request to forward the texts of both the protest and the decision thereon to the designated Offices.
 - ☐ no decision has been made yet on the protest: the applicant will be notified as soon as a decision is made.
4. Further action(s): The applicant is reminded of the following:
 Shortly after 18 months from the priority date, the international application will be published by the International Bureau. If the applicant wishes to avoid or postpone publication, a notice of withdrawal of the international application, or of the priority claim, must reach the International Bureau as provided in Rules 90bis.1 and 90bis.3, respectively, before the completion of the technical preparations for international publication.
 Within 19 months from the priority date, a demand for international preliminary examination must be filed if the applicant wishes to postpone the entry into the national phase until 30 months from the priority date (in some Offices even later).
 Within 20 months from the priority date, the applicant must perform the prescribed acts for entry into the national phase before all designated Offices which have not been elected within 19 months from the priority date or could not be elected because they are not bound by Chapter II.

| | |
|---|---|
| Name and mailing address of the ISA/ Patent- och registreringsverket Box 5055 S-102 42 STOCKHOLM Facsimile No. 08-667 72 88 | Authorized officer <div style="text-align: center; font-family: cursive;">Anne Vilval</div> Telephone No. 08-782 25 00 |
|---|---|

PCT

INTERNATIONAL SEARCH REPORT

(PCT Article 18 and Rules 43 and 44)

| | | |
|--|--|---|
| Applicant's or agent's file reference 3774 PCT | FOR FURTHER ACTION see Notification of Transmittal of International Search Report (Form PCT/ISA/220) as well as, where applicable, item 5 below. | |
| International application No. PCT/SE 00/00470 | International filing date (day/month/year) 9 March 2000 | (Earliest) Priority Date (day/month/year) 12 March 1999 |
| Applicant CelsiusTech Electronics AB et al | | |

This international search report has been prepared by this International Searching Authority and is transmitted to the applicant according to Article 18. A copy is being transmitted to the International Bureau.

This international search report consists of a total of 3 sheets.

☒ It is also accompanied by a copy of each prior art document cited in this report.

1. ☐ Certain claims were found unsearchable (See Box I).
2. ☐ Unity of invention is lacking (See Box II).
3. ☐ The international application contains disclosure of a nucleotide and/or amino acid sequence listing and the international search was carried out on the basis of the sequence listing
 - ☐ filed with the international application.
 - ☐ furnished by the applicant separately from the international application,
 - ☐ but not accompanied by a statement to the effect that it did not include matter going beyond the disclosure in the international application as filed.
 - ☐ transcribed by this Authority.
4. With regard to the title, ☐ the text is approved as submitted by the applicant.
☒ the text has been established by this Authority to read as follows:

Quantum well based two-dimensional detector for IR
radiation and camera system with such a detector
5. With regard to the abstract,
 - ☒ the text is approved as submitted by the applicant.
 - ☐ the text has been established, according to Rule 38.2(b), by this Authority as it appears in Box III. The applicant may, within one month from the date of mailing of this international search report, submit comments to this Authority.
6. The figure of the drawings to be published with the abstract is:
 Figure No. 3 ☒ as suggested by the applicant. ☐ None of the figures.
☐ because the applicant failed to suggest a figure.
☐ because this figure better characterizes the invention.

A. CLASSIFICATION OF SUBJECT MATTER

IPC7: H01L 31/0236, H01L 31/09, G01J 5/20, H04N 5/33
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC7: H01L, G01J, H04N

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
SE,DK,FI,NO classes as above

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

| Category* | Citation of document, with indication, where appropriate, of the relevant passages | Relevant to claim No. |
|-----------|--|-----------------------|
| A | EP 0617471 A2 (NIPPON TELEGRAPH AND TELEPHONE CO.), 28 Sept 1994 (28.09.94), column 9, claim 15 -- | 1-10 |
| A | US 5485015 A (KWONG-KIT CHOI), 16 January 1996 (16.01.96), figures 7,8 -- | 1-10 |
| A | US 5539206 A (THOMAS R. SCHIMERT), 23 July 1996 (23.07.96), abstract -- | 1-10 |

☒ Further documents are listed in the continuation of Box C.

☒ See patent family annex.

* Special categories of cited documents:

- "A" document defining the general state of the art which is not considered to be of particular relevance
- "E" earlier document but published on or after the international filing date
- "L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
- "O" document referring to an oral disclosure, use, exhibition or other means
- "P" document published prior to the international filing date but later than the priority date claimed

"I" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance: the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance: the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search

Date of mailing of the international search report

6 July 2000

14 -07- 2000

Name and mailing address of the ISA/
Swedish Patent Office
Box 5055, S-102 42 STOCKHOLM
Facsimile No. +46 8 666 02 86

Authorized officer

STURE ELNÄS/EE
Telephone No. +46 8 782 25 00

INTERNATIONAL SEARCH REPORT

International application No.

PCT/SE 00/00470

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

| Category* | Citation of document, with indication, where appropriate, of the relevant passages | Relevant to claim No. |
|-----------|--|-----------------------|
| A | IEEE ELECTRON DEVICE LETTERS, Volume 16, No 2, February 1995, K. L. Tsai et al, "Two-Dimensional Bi-Periodic Grating Coupled One- and Two-Color Quantum Well Infrared Photodetectors", column 2, line 7, figure 1 ----- | 1-10 |

INTERNATIONAL SEARCH REPORT

Information on patent family members

02/12/99

International application No.

PCT/SE 00/00470

| Patent document cited in search report | Publication date | Patent family member(s) | Publication date |
|---|---------------------|----------------------------|---------------------|
| EP 0617471 A2 | 28/09/94 | JP 7231144 A | 29/08/95 |
| | | US 5585957 A | 17/12/96 |
| | | US 5689358 A | 18/11/97 |
| ----- | | | |
| US 5485015 A | 16/01/96 | NONE | |
| ----- | | | |
| US 5539206 A | 23/07/96 | CA 2220834 A | 24/10/96 |
| | | EP 0824762 A | 25/02/98 |
| | | JP 11504763 T | 27/04/99 |
| | | NO 974814 A | 17/10/97 |
| | | WO 9633515 A | 24/10/96 |
| ----- | | | |

From the INTERNATIONAL BUREAU

PCT

**NOTICE INFORMING THE APPLICANT OF THE
COMMUNICATION OF THE INTERNATIONAL
APPLICATION TO THE DESIGNATED OFFICES**

(PCT Rule 47.1(c), first sentence)

To:

FORSBERG, Carl-Göran
Bofors Support AB
Patents and Trademarks
S-691 80 Karlskoga
SUÈDE

| | | |
|---|---|---|
| Date of mailing (day/month/year) 21 September 2000 (21.09.00) | | |
| Applicant's or agent's file reference 3774 PCT | | IMPORTANT NOTICE |
| International application No. PCT/SE00/00470 | International filing date (day/month/year) 09 March 2000 (09.03.00) | Priority date (day/month/year) 12 March 1999 (12.03.99) |
| Applicant CELSIUSTECH ELECTRONICS AB et al | | |

1. Notice is hereby given that the International Bureau has communicated, as provided in Article 20, the international application to the following designated Offices on the date indicated above as the date of mailing of this Notice:
AU,KP,KR,US

In accordance with Rule 47.1(c), third sentence, those Offices will accept the present Notice as conclusive evidence that the communication of the international application has duly taken place on the date of mailing indicated above and no copy of the international application is required to be furnished by the applicant to the designated Office(s).

2. The following designated Offices have waived the requirement for such a communication at this time:

**AE,AL,AM,AP,AT,AZ,BA,BB,BG,BR,BY,CA,CH,CN,CU,CZ,DE,DK,EA,EE,EP,ES,FI,GB,GD,GE,GH,
GM,HR,HU,ID,IL,IN,IS,JP,KE,KG,KZ,LC,LK,LR,LS,LT,LU,LV,MD,MG,MK,MN,MW,MX,NO,NZ,OA,
PL,PT,RO,RU,SD,SE,SG,SI,SK,SL,TJ,TM,TR,TT,UA,UG,UZ,VN,YU,ZA,ZW**

The communication will be made to those Offices only upon their request. Furthermore, those Offices do not require the applicant to furnish a copy of the international application (Rule 49.1(a-bis)).

3. Enclosed with this Notice is a copy of the international application as published by the International Bureau on
 21 September 2000 (21.09.00) under No. WO 00/55922

REMINDER REGARDING CHAPTER II (Article 31(2)(a) and Rule 54.2)

If the applicant wishes to postpone entry into the national phase until 30 months (or later in some Offices) from the priority date, a **demand for international preliminary examination** must be filed with the competent International Preliminary Examining Authority before the expiration of 19 months from the priority date.

It is the applicant's sole responsibility to monitor the 19-month time limit.

Note that only an applicant who is a national or resident of a PCT Contracting State which is bound by Chapter II has the right to file a demand for international preliminary examination.

REMINDER REGARDING ENTRY INTO THE NATIONAL PHASE (Article 22 or 39(1))

If the applicant wishes to proceed with the international application in the **national phase**, he must, within 20 months or 30 months, or later in some Offices, perform the acts referred to therein before each designated or elected Office.

For further important information on the time limits and acts to be performed for entering the national phase, see the Annex to Form PCT/IB/301 (Notification of Receipt of Record Copy) and Volume II of the PCT Applicant's Guide.

| | |
|--|--|
| The International Bureau of WIPO 34, chemin des Colombettes 1211 Geneva 20, Switzerland Facsimile No. (41-22) 740.14.35 | Authorized officer <p style="text-align: center;">J. Zahra</p> Telephone No. (41-22) 338.83.38 |
|--|--|

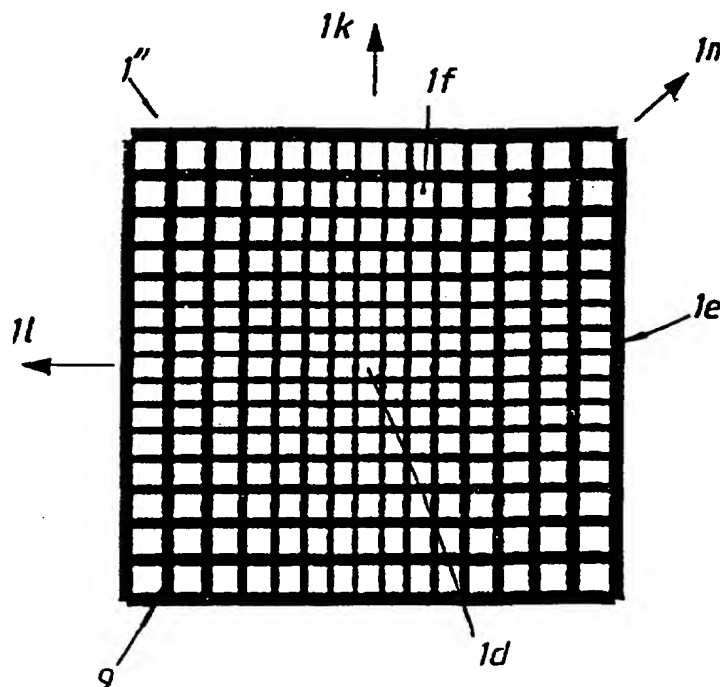
INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

| | | | |
|---|--|---|---|
| (51) International Patent Classification ⁷ : H01L 31/0236, 31/09, G01J 5/20, H04N 5/33 | | A1 | (11) International Publication Number: WO 00/55922 |
| | | | (43) International Publication Date: 21 September 2000 (21.09.00) |
| (21) International Application Number: PCT/SE00/00470 (22) International Filing Date: 9 March 2000 (09.03.00) (30) Priority Data: 9900885-6 12 March 1999 (12.03.99) SE (71) Applicant (for all designated States except US): CEL- SIUSTECH ELECTRONICS AB [SE/SE]; S-175 88 Järfälla (SE). (72) Inventor; and (75) Inventor/Applicant (for US only): LINDAU, Sten [SE/SE]; Libbyvägen 56, S-187 62 Täby (SE). (74) Agent: FORSBERG, Carl-Göran; Bofors Support AB, Patents and Trademarks, S-691 80 Karlskoga (SE). | | (81) Designated States: AE, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, CA, CH, CN, CU, CZ, DE, DK, EE, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MD, MG, MK, MN, MW, MX, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TR, TT, UA, UG, US, UZ, VN, YU, ZA, ZW, ARIPO patent (GH, GM, KE, LS, MW, SD, SL, SZ, TZ, UG, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GW, ML, MR, NE, SN, TD, TG). Published <i>With international search report.</i> <i>Before the expiration of the time limit for amending the</i> <i>claims and to be republished in the event of the receipt of</i> <i>amendments.</i> <i>In English translation (filed in Swedish).</i> | |

(54) Title: QUANTUM WELL BASED TWO-DIMENSIONAL DETECTOR FOR IR RADIATION AND CAMERA SYSTEM WITH SUCH A DETECTOR

(57) Abstract

A quantum well based two-dimensional detector (1) for detecting infrared radiation which receives infrared radiation falling upon its detector surface (1a) at various angles of incidence. The detector comprises a grating arrangement for diffraction of the incident radiation. The arrangement is selected with a grating interval which varies or changes from the central part of the detector out towards the outer parts of the detector. The variation or change in the grating interval is arranged to retain in the detection diffracted rays of the orders 1 and -1 as active components over the whole detector surface by changing the angle values of the diffracted rays depending upon the angles of incidence of the radiation falling on various parts of the detector surface.



FOR THE PURPOSES OF INFORMATION ONLY

Codes used to identify States party to the PCT on the front pages of pamphlets publishing international applications under the PCT.

| | | | | | | | |
|----|--------------------------|----|--|----|--|----|--------------------------|
| AL | Albania | ES | Spain | LS | Lesotho | SI | Slovenia |
| AM | Armenia | FI | Finland | LT | Lithuania | SK | Slovakia |
| AT | Austria | FR | France | LU | Luxembourg | SN | Senegal |
| AU | Australia | GA | Gabon | LV | Latvia | SZ | Swaziland |
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| CA | Canada | IT | Italy | NE | Niger | UZ | Uzbekistan |
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| CH | Switzerland | KG | Kyrgyzstan | NZ | New Zealand | ZW | Zimbabwe |
| CI | Côte d'Ivoire | KP | Democratic People's Republic of Korea | PL | Poland | | |
| CM | Cameroon | KR | Republic of Korea | PT | Portugal | | |
| CN | China | KZ | Kazakstan | RO | Romania | | |
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| DK | Denmark | LR | Liberia | SG | Singapore | | |
| EE | Estonia | | | | | | |

Quantum well based two-dimensional detector for IR radiation and camera system with such a detector

5

This invention concerns a quantum well based two-dimensional detector for detecting infrared radiation which receives infrared radiation falling upon its detector surface at various angles of incidence within a range of 0-30° in relation to the normal to the surface. The detector comprises a grating arrangement for diffraction of the incident radiation. The invention also concerns a camera system for infrared radiation and comprising optics with an aperture and cooling unit and a quantum well based two-dimensional detector which receives via the aperture infrared radiation falling at various angles of incidence within a range of 0-30° in relation to the normal to the detector surface. The detector comprises in addition a grating arrangement for diffraction of the incident radiation.

The use of diffraction gratings of various kinds is already known for the purpose of increasing the sensitivity of a quantum well based detector for detecting infrared radiation, a so-called QWIP detector (Quantum Well Infrared Photodetector). Reference can be made to the Swedish patent 9101034 and the American patents 5 075 749 and 5 506 419. QWIP detectors are completely insensitive to radiation which falls perpendicular to the surface, but by the introduction of a grating the direction of the incident radiation can be changed so that this can be absorbed by the detector structure. The grating is normally arranged so that the detector is most sensitive to radiation falling perpendicular to the detector surface.

The use of such detectors in IR camera systems is already known, where the detectors are combined with optics and cooling devices. An important component in

this respect is the so-called cold aperture which is usually integrated with the detector in a vacuum flask (Dewar vessel). The cold aperture limits the angles of incidence of the radiation which falls on the detector.

5 A QWIP detector which is equipped with a through-put grating as above is usually sensitive within a relatively narrow range of angles. In particular this applies when a grating arrangement is used in accordance with the abovementioned Swedish patent,
10 where the grating constant or grating interval is selected so that the angles of diffraction are almost 90° . It only requires a very small change in the angle of incidence for the angle of diffraction to exceed 90° in relation to the normal to the detector surface
15 whereupon the diffracted ray in question is lost as an active component in the detection, which results in a sudden reduction in the through-put efficiency.

In order for radiation to be detected by the detector it is necessary for the angles of incidence to
20 lie within a range of angles where the detector is sensitive. For points which lie straight in front of the detector, that is straight in front of the cold aperture, all these rays will lie within a range of angles around 0° , which means that most of the radiation
25 can be detected. On the other hand for points at the edge of the detector surface the rays fall principally at oblique angles, where previously known detectors have poor sensitivity. This is shown in figures 1 and 2 where A shows the radiation falling on the centre of
30 the detector surface via the cold aperture and B shows the radiation falling on the outer edges of the detector surface via the cold aperture. There is a need to be able to obtain even sensitivity over the whole detector surface in order to be able to achieve a
35 better picture quality. This invention aims to solve this problem, among others.

In connection with the camera system there is also the requirement to be able to make the optics smaller

and reduce the cooling requirement in the system. The invention also intends to solve this problem.

A detector according to the invention can principally be characterized in that the grating arrangement is selected with a grating interval which varies or changes from the central part of the detector or the detector surface out towards the outer parts or circumference of the detector or detector surface. It is further characterized in that the variation or change in the grating interval is arranged to retain or contribute towards retaining in the detection diffracted rays of the orders of 1 and -1 as active components over the whole detector surface by changing the angle value of the diffracted rays depending upon the angles of incidence of the radiation falling upon the various parts of the detector surface.

In the embodiments of the invention concept it is proposed that the grating interval varies linearly or in steps. Elements included in the grating arrangement vary in the horizontal cross-section of the grating arrangement in configuration size and/or shape and are, for example, square in the central part of the detector surface and change to a rectangular form in the part of the grating arrangement towards the outer parts or around the circumference of the detector surface. Further embodiments of the invention concept are described in the following patent claims regarding the construction of the detector.

A camera system according to the invention can principally be characterized in that, as described above, the grating arrangement is selected with a grating interval which varies or changes from the central part of the detector out towards the outer parts of the detector and that the grating interval or the change is selected to diffract rays which pass through the edge of the aperture, that is rays with the largest angle of incidence, by a value up to or exactly equal to 90° in relation to the normal to the detector surface. Other rays which pass through the aperture are

diffracted by smaller angles than the abovementioned value, but are still close to 90° . The abovementioned values are selected preferably within the range approximately $85^\circ - 90^\circ$.

5 By means of the invention described above a more even and more stable sensitivity is obtained over the whole detector surface which, as described above, gives a better picture quality. In connection with the new camera system this can be further refined in relation
10 to the current technology.

DESCRIPTION OF THE FIGURES:

In the following a currently proposed embodiment of a detector and a camera system according to the
15 invention will be described with reference to the attached figures, where

figure 1 shows in principal diagram form and from the side IR radiation falling through an aperture onto the centre of the detector surface in accordance with already known technology,
20

figure 2 shows in principal diagram form and from the side radiation falling through an aperture onto the outer edge of the detector related to the sensitivity area of the detector, where the figure shows the case for known technology,
25

figure 3 shows in horizontal view from underneath and in principle a first embodiment of a detector with the new grating arrangement, not to scale,
30

figure 4 shows in horizontal view from underneath and in principle a second embodiment of the detector's grating arrangement, not to scale,
35

figure 5 shows in diagrammatic form the linearly increasing grating interval from the centre of the detector surface out towards one outer edge of the detector surface,

- figure 6 shows in diagrammatic form the grating interval increasing or changing in steps from the centre of the detector surface out towards one outer edge of the detector,
- 5 figure 7 shows in principal diagram form the case when diffracted rays are lost as active components in reproduction in detectors of known types, and
- 10 figure 8 shows in principal diagram form the diffraction of the infrared radiation falling on the detector surface at an angle via the aperture in accordance with the invention where the rays falling on the first edge of the detector surface are reproduced.
- 15 Figures 1 and 2 refer principally to the problems which are associated with already known detectors and camera systems. Figure 1 shows a radiation area A for the incident infrared radiation which falls on the detector 1 at the central parts 1b of its detector
- 20 surface 1a. Detector 1 can be of a known type and in this connection reference is made to the Swedish and American patents mentioned in the introduction which concern the construction of a so-called QWIP detector. A so-called cold aperture is indicated by 2. The
- 25 centrally incident radiation is shown by arrows and lines 3 and 4. The detector is principally sensitive within an area which is represented by the angle α . From the figure it can be seen that the area of sensitivity (the cone) covers the whole of the opening
- 30 of the aperture 2a. The incident radiation 3, 4 falls within the area of sensitivity 5, 6 of the detector over all its extent, which indicates that the detector has a high degree of sensitivity for the incident radiation.
- 35 Figure 2 shows that the area of sensitivity of the detector 1' at the outer edge 1c of the detector surface 1a' is only partially accessible to infrared radiation falling at oblique angles, which area is indicated by β . Only a small part can therefore be

detected by the detector, which gives a lower degree of sensitivity for the reception by the detector of the incident oblique radiation. The area of sensitivity of the detector only covers a part of the incident radiation 3', 4'. See also the broken lines 5', 6' in figure 2 which show that the area of sensitivity only partially covers the opening 2a' in the aperture. Figure 2 also shows the construction of an IR camera K based on the QWIP detector 1'. The camera comprises an optics part O and a cooling unit KE. The abovementioned components are already known and are incorporated in the camera body KS in a known way. In figure 2 the diameter of the aperture is indicated by D and the distance between the aperture and the upper surface 1a' of the detector is indicated by S.

In accordance with the invention the grating structure is to be changed according to the angle of incidence of the incident radiation. This means preferably that the grating interval is longer at the edge of the detector than in the centre. The grating is preferably two-dimensional in order to be insensitive to polarization of the radiation. Figure 3 shows a grating arrangement viewed from the underside of the detector in question. The detector is indicated in the diagram by 1". The grating element in the embodiment is constructed with quadrilateral configurations. At the central parts 1d of the grating arrangement or of the detector the grating elements are essentially square while at the outer edge 1e of the detector they are essentially rectangular. A grating element is indicated by 1f in figure 3. The figure is not drawn to scale, but is only an outline diagram.

In accordance with a first embodiment of the invention concept the grating interval varies linearly from the centre 1d of the detector out towards the outer edge 1e of the detector.

The abovementioned variation or change in the grating interval can according to figure 4 be arranged in steps increasing out from the central part 1d' of

the detector to the outer edge $1e'$ of the detector. In the embodiment according to figure 4 the increase in steps in the grating arrangement is arranged using strip-shaped formations $1g$ and $1h$ which in principle cross each other at the central part $1d'$ of the detector. In this way a first density in the grating arrangement is obtained in the area which is covered by both strips $1g$ and $1h$. In parts which are individually covered by the strip-shaped arrangements $1g$ and $1h$ a second density is obtained in the grating arrangement. In the corners of the grating arrangement which are symbolized by $1i$ a third density is obtained for the grating arrangement. The corners $1i$ are not crossed by the strip-shaped structures $1g$ and $1h$. The grating interval is smaller at the central parts and increases out towards the outer parts.

The grating arrangement can extend from the central parts of the detector surface out towards the outer edges of the detector surface with grating intervals or steps increasing in principle in all directions which are indicated by $1k$, $1l$, $1m$ and $1k'$, $1l'$, $1m'$ respectively in figure 1.

Figure 5 is intended to show the linearly increasing grating interval in the grating arrangement from the central part $1d$ of the detector $1''$ out towards its straight outer edge $1e$. In a corresponding way figure 6 is intended to show the grating interval increasing in steps from the centre $1d'$ of the detector $1'''$ out towards the outer edge $1e'$ in figure 4.

Figure 7 is intended to show the situation with already known technology. In this case the aperture is indicated by $2a''$ and the incident ray with the largest angle to the upper surface $1a''$ of the detector is indicated by 7. Figure 7 is intended to show that diffracted rays of the order 1 have been given an angle β in relation to the normal 8 to the surface, which angle is greater than 90° . This means that the rays in question are lost as active components in the detection or recording. In figure 7 an angle (γ) is indicated

between the incident radiation and the normal 8 to the surface. This maximum angle is preferably selected within the range 0-45°.

Figure 8 shows the improvement according to the invention. The incident radiation 7' which corresponds to the incident radiation 7 in figure 7 is diffracted with diffraction rays of the orders 1 and -1 according to the figure. By the suitable selection of the grating interval the diffraction rays of the order 1 assume a value β' which is 90° or very near 90°, which means that the rays in question can be retained as active components, which means that the sensitivity of the detector is increased.

In a preferred embodiment the variation of the grating interval is selected over the detector surface in accordance with the following. The starting point is a given aperture diameter D (see figure 2) at the distance S (see figure 2) from the surface 1a' of the detector. A grating interval $d(x)$ for a point at the distance x (see figure 2) from the centre 1d of the detector (see figure 3) is selected in such a way that the ray which has the largest angle of incidence is diffracted by precisely 90° in relation to the normal. This ray passes precisely at the edge of the aperture. All other rays which pass through have a smaller angle of incidence and are therefore diffracted by angles less than but close to 90° (see above). Expressed mathematically the grating interval is:

$$d(x) = \frac{\lambda}{n - \sin \alpha_{0\max}(x)}$$

where λ is the wavelength, n is the diffraction index of the grating substrate and $\alpha_{0\max}(x)$ is the maximum angle of incidence and is given by the formula:

$$\tan \alpha_{0\max}(x) = \frac{x + D/2}{S}$$

In a second preferred embodiment the grating interval is selected according to a simplified method derived from the method above, by approximation of $\sin\alpha_{0\max}$ and $\tan\alpha_{0\max}$ by $\alpha_{0\max}$. The grating interval is
 5 then given by

$$d(x) = \frac{\lambda}{n} \left(1 + \frac{D}{2nS} + \frac{x}{nS} \right)$$

that is the grating interval varies linearly from the
 10 centre out towards the edges.

In an embodiment the following values are selected: $\lambda = 9 \mu\text{m}$, $D = 7 \text{ mm}$ and $S = 14 \text{ mm}$. For the substrate or the material GaAs $n = 3.28$. At the centre of the detector $d = 2.95$. At the edge, for example 8 mm
 15 from the centre, $d = 3.43 \mu\text{m}$. In an embodiment d is selected at the centre of the detector within a range 2.5 - 3.0 μm and at the outer edge of the detector within a range 3.0 - 3.5 μm , where the higher values are related to each other within both areas, as are the
 20 lower values.

Selection of the grating interval d for the value of β' equal to or close to 90° is obtained by means of

$$\frac{\sin\alpha_0}{n} + \sin\beta_m = \frac{m\lambda}{nd}$$

25

The abovementioned grating arrangement has been given the designation 9 in figure 3 and a graph for the periodicity according to figure 3 has been given the designation 10 in figure 5, while the graph for the
 30 periodicity according to figure 4 has been given the designation 11 in figure 6.

This invention is not restricted to the embodiments described above, but can be modified within the framework of the following patent claims and
 35 invention concept.

PATENT CLAIMS:

1. Quantum well based two-dimensional detector 1 for detecting infrared radiation 3, 4 which receives
5 infrared radiation falling upon its detector surface 1a at various angles of incidence preferably within a range of 0-45° in relation to the normal 8 to the surface and comprising a grating arrangement 1f for diffraction of the incident radiation, characterized in
10 that the grating arrangement is selected with a grating interval which varies or changes from the central part 1d of the detector out towards the outer parts 1e or circumference of the detector, and that the variation or change in the grating interval is arranged to retain
15 or contribute towards retaining in the detection diffracted rays of the orders 1 and -1 as active components across the whole detector surface by changing the angle values of the diffracted rays depending upon the angles of incidence α of the
20 radiation falling on the various parts of the detector surface.
2. Detector according to claim 1, characterized in that the grating interval varies linearly.
3. Detector according to claim 1, characterized in
25 that the grating interval varies in steps.
4. Detector according to claim 1, 2 or 3, characterized in that elements 1f incorporated in the grating arrangement 9 in the horizontal section of the grating arrangement vary the configuration size and/or
30 shape and for example are square at the central part 1d of the detector surface and change to rectangular shapes as the grating arrangement 9 extends out towards the outer parts 1e or circumference of the detector surface.
- 35 5. Detector according to any of the preceding claims, characterized in that the interval 10, 11 of the grating arrangement is selected so that the detection or sensitivity of the detector is essentially the same over the whole surface 1a of the detector.

6. Detector according to any of the preceding claims, characterized in that the grating interval increases with the distance from the central parts of the detector out towards its outer parts or circumference
 5 1e.

7. Detector according to claim 1 or any of claims 2-6, characterized in that the grating interval varies according to

$$10 \quad d(x) = \frac{\lambda}{n \cdot \sin \alpha_{0\max}(x)}$$

where λ is the wavelength, n is the diffraction index of the grating substrate and $\alpha_{0\max}(x)$ is the maximum angle of incidence and is given by the formula

$$15 \quad \tan \alpha_{0\max}(x) = \frac{x + D/2}{S}$$

8. Detector according to claim 7, characterized in that the grating interval is selected by approximation of $\sin \alpha_{0\max}$ and $\tan \alpha_{0\max}$ by $\alpha_{0\max}$, where the grating
 20 interval is given by

$$d(x) = \frac{\lambda}{n} \left(1 + \frac{D}{2nS} + \frac{x}{nS} \right),$$

that is the grating interval varies linearly from the
 25 centre out towards the edges.

9. Detector according to claim 1 or any of claims 2-7, characterized in that the grating interval has values of approximately 2.5-3.0 micrometres at the centre of the detector and approximately 3.0-3.5
 30 micrometres at the outer parts of the detector, where the higher values within both areas are related to each other and the lower values within both areas are related to each other.

10. Camera system for infrared radiation and
 35 comprising optics O with aperture 2 and cooling unit KE and a quantum well based two-dimensional detector 1

which receives via the aperture infrared radiation 3, 4 falling at various angles of incidence α preferably within a range of 0-45° in relation to the normal 8 to the detector surface, where the detector comprises a

5 grating arrangement for diffraction of the incident radiation characterized in that the grating arrangement is selected with a grating interval which varies or changes from the centre of the detector out towards the

10 outer parts of the detector and in that the grating interval or the change is selected to diffract the rays 7' which pass through the edge of the aperture 2a", that is the rays with the largest angle of incidence, by a value up to or exactly equal to 90° and to diffract

15 rays with smaller angles of incidence by values which are less than the abovementioned value but are still close to 90°, which values are preferably selected within the range 85° - 90°.

Fig. 1

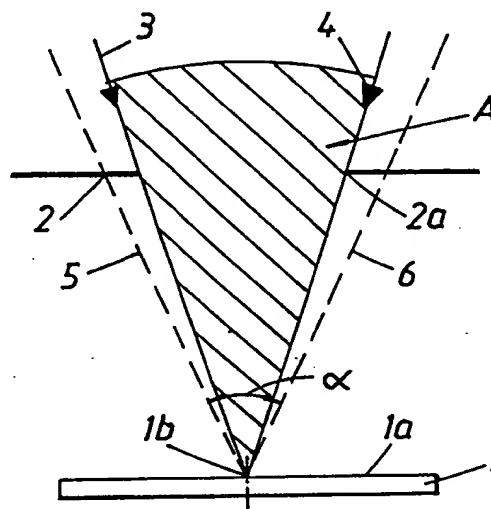


Fig. 2

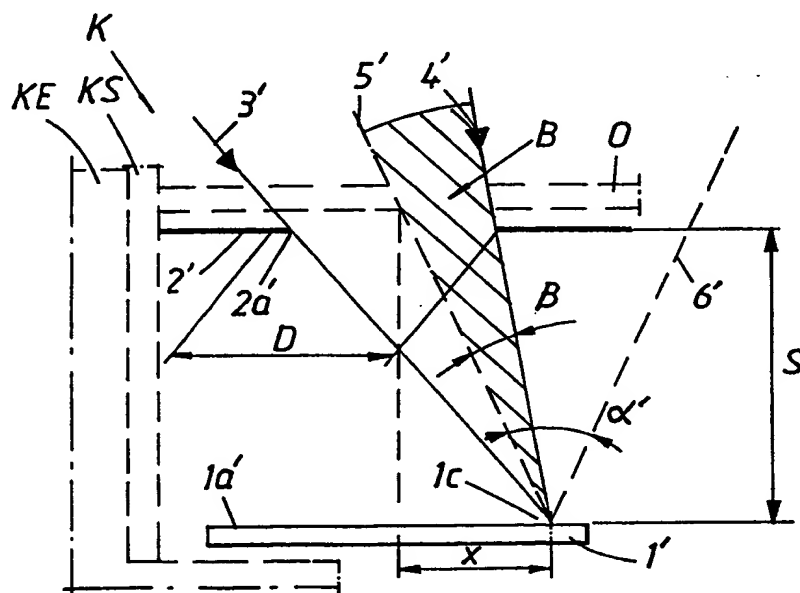


Fig. 4

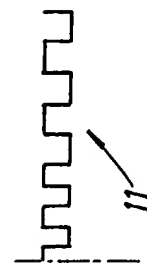
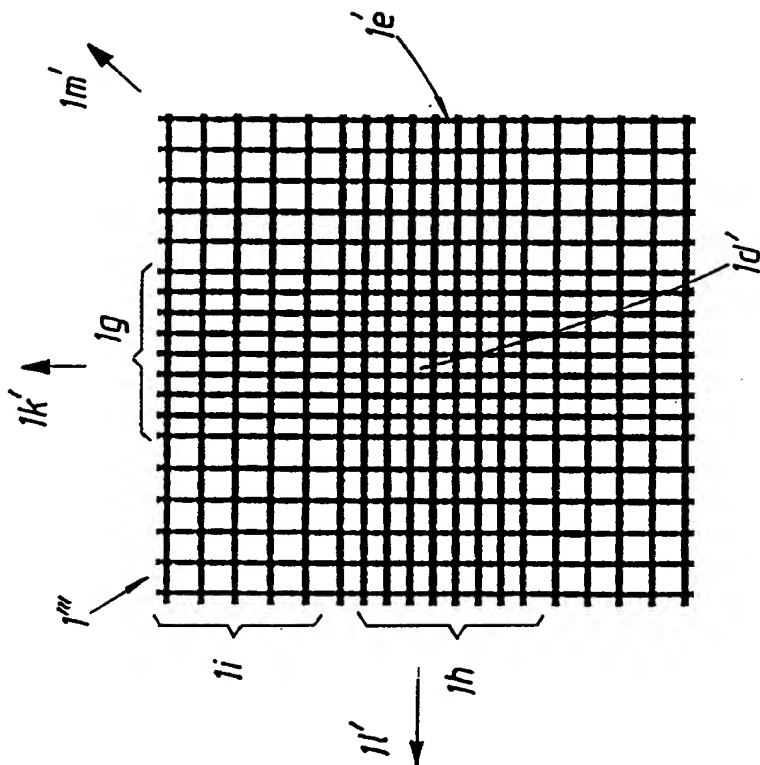


Fig. 6

Fig. 3

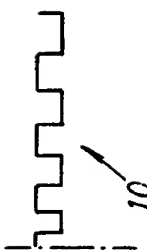
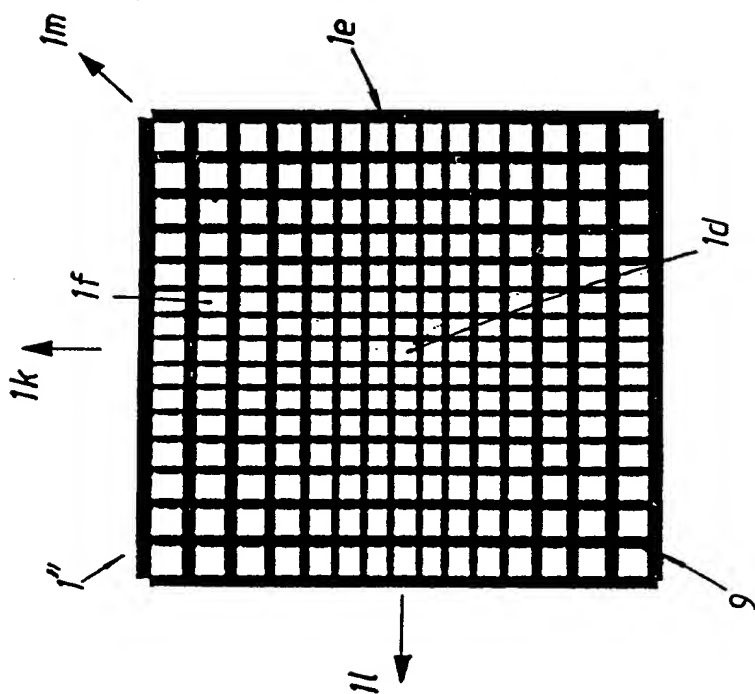


Fig. 5

Fig. 7

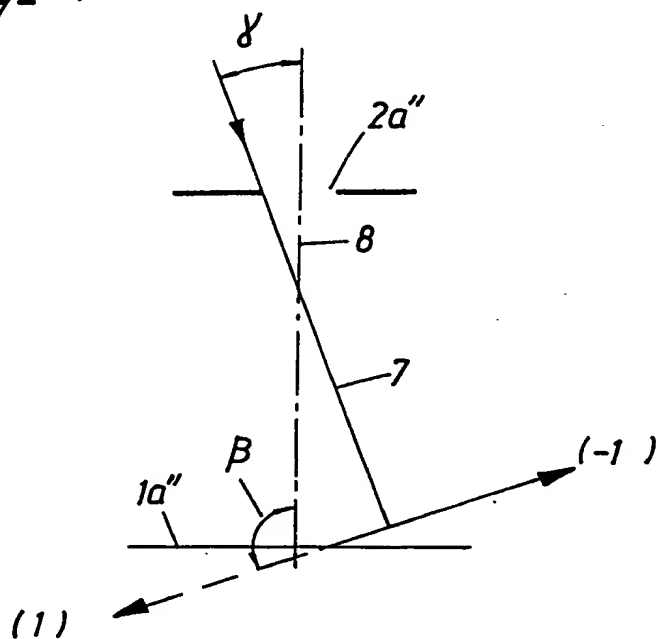
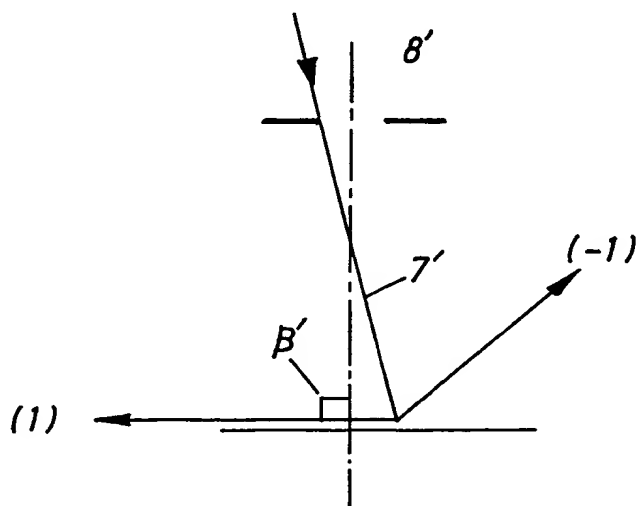


Fig. 8



INTERNATIONAL SEARCH REPORT

International application No.

PCT/SE 00/00470

A. CLASSIFICATION OF SUBJECT MATTER

IPC7: H01L 31/0236, H01L 31/09, G01J 5/20, H04N 5/33
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC7: H01L, G01J, H04N

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

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Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

| Category* | Citation of document, with indication, where appropriate, of the relevant passages | Relevant to claim No. |
|-----------|--|-----------------------|
| A | EP 0617471 A2 (NIPPON TELEGRAPH AND TELEPHONE CO.), 28 Sept 1994 (28.09.94), column 9, claim 15 -- | 1-10 |
| A | US 5485015 A (KWONG-KIT CHOI), 16 January 1996 (16.01.96), figures 7,8 -- | 1-10 |
| A | US 5539206 A (THOMAS R. SCHIMERT), 23 July 1996 (23.07.96), abstract -- | 1-10 |

☒ Further documents are listed in the continuation of Box C.☒ See patent family annex.

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Date of the actual completion of the international search

6 July 2000

Date of mailing of the international search report

14 -07- 2000

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International application No.

PCT/SE 00/00470

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

| Category* | Citation of document, with indication, where appropriate, of the relevant passages | Relevant to claim No. |
|-----------|---|-----------------------|
| A | IEEE ELECTRON DEVICE LETTERS, Volume 16, No 2, February 1995, K. L. Tsai et al, "Two-Dimensional Bi-Periodic Grating Coupled One- and Two-Color Quantum Well Infrared Photodetectors", column 2, line 7, figure 1 ----- ----- | 1-10 |

INTERNATIONAL SEARCH REPORT

Information on patent family members

02/12/99

International application No.

PCT/SE 00/00470

| Patent document cited in search report | | | Publication date | Patent family member(s) | | Publication date |
|---|---------|----|---------------------|----------------------------|------------|---------------------|
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| ----- | | | | | | |
| US | 5485015 | A | 16/01/96 | NONE | | |
| ----- | | | | | | |
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| | | | | EP | 0824762 A | 25/02/98 |
| | | | | JP | 11504763 T | 27/04/99 |
| | | | | NO | 974814 A | 17/10/97 |
| | | | | WO | 9633515 A | 24/10/96 |
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REQUEST

The undersigned requests that the present international application be processed according to the Patent Cooperation Treaty.

2000-04-06

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| PCT/SE 00 / 0 0 4 7 0 | |
| International Application No. | |
| 2000-03-09 | |
| International Filing Date | |
| The Swedish Patent Office PCT International Application | |
| Name of receiving Office and "PCT International Application" | |
| Applicant's or agent's file reference (if desired) (12 characters maximum) 3774 PCT | |

| | |
|---|---|
| Box No. I TITLE OF INVENTION | |
| Quantum well based two-dimensional detector for IR radiation and camera system with such a detector | |
| Box No. II APPLICANT | |
| Name and address: (Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country. The country of the address indicated in this Box is the applicant's State (that is, country) of residence if no State of residence is indicated below.) | |
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| <input checked="" type="checkbox"/> LC Saint Lucia | |
| <input checked="" type="checkbox"/> LK Sri Lanka | |

Precautionary Designation Statement: In addition to the designations made above, the applicant also makes under Rule 4.9(b) all other designations which would be permitted under the PCT except any designation(s) indicated in the Supplemental Box as being excluded from the scope of this statement. The applicant declares that those additional designations are subject to confirmation and that any designation which is not confirmed before the expiration of 15 months from the priority date is to be regarded as withdrawn by the applicant at the expiration of that time limit. (Confirmation of a designation consists of the filing of a notice specifying that designation and the payment of the designation and confirmation fees. Confirmation must reach the receiving Office within the 15-month time limit.)

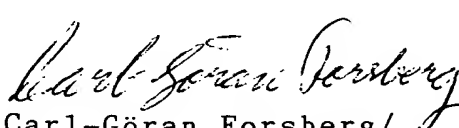
| Box No. VI PRIORITY CLAIM | | | | | <input type="checkbox"/> Further priority claims are indicated in the Supplemental Box. |
|---|----------------------------------|----------------------------------|---|--|---|
| Filing date of earlier application (day/month/year) | Number of earlier application | Where earlier application is: | | | |
| | | national application: country | regional application:* regional Office | international application: receiving Office | |
| item (1) 12.3.1999 | 9900885-6 | SE | | SE | |
| item (2) | | | | | |
| item (3) | | | | | |

☒ The receiving Office is requested to prepare and transmit to the International Bureau a certified copy of the earlier application(s) (only if the earlier application was filed with the Office which for the purposes of the present international application is the receiving Office) identified above as item(s): (1)

* Where the earlier application is an ARIPO application, it is mandatory to indicate in the Supplemental Box at least one country party to the Paris Convention for the Protection of Industrial Property for which that earlier application was filed (Rule 4.10(b)(ii)). See Supplemental Box.

| | | | |
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| ISA/ | | Date (day/month/year) 12 March 1999 | Number SE 99/00342 |
| | | Country (or regional Office) SE | |

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|  /Carl-Göran Forsberg/ | |

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| 3. Corrected date of actual receipt due to later but timely received papers or drawings completing the purported international application: | |
| 4. Date of timely receipt of the required corrections under PCT Article 11(2): | |
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2000-04-06

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Fig. 1

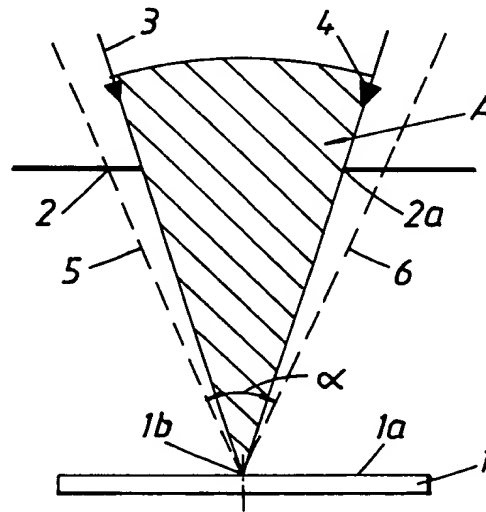
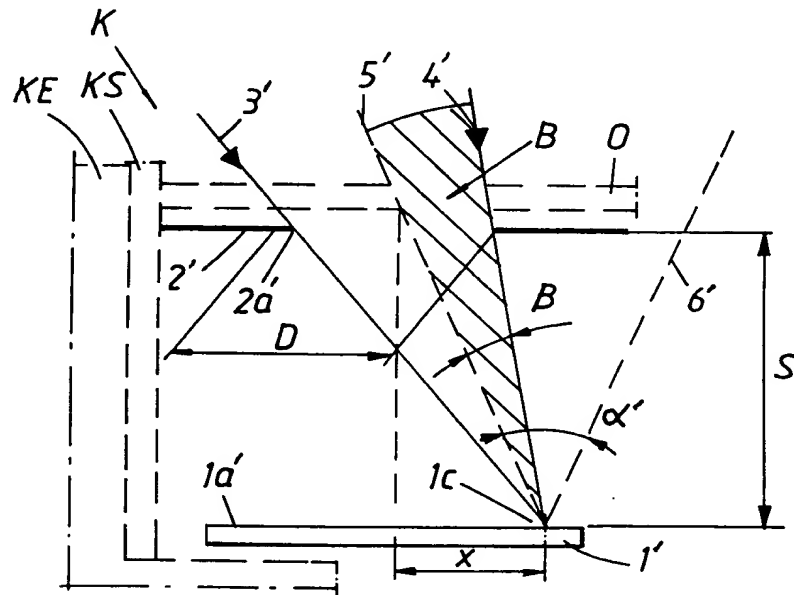
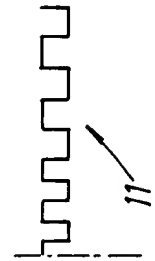
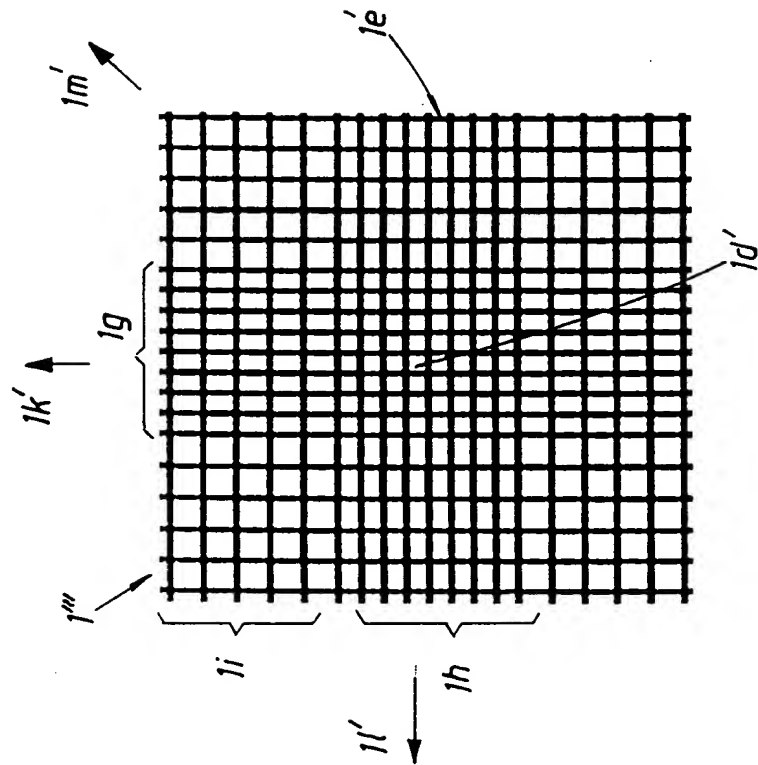


Fig. 2

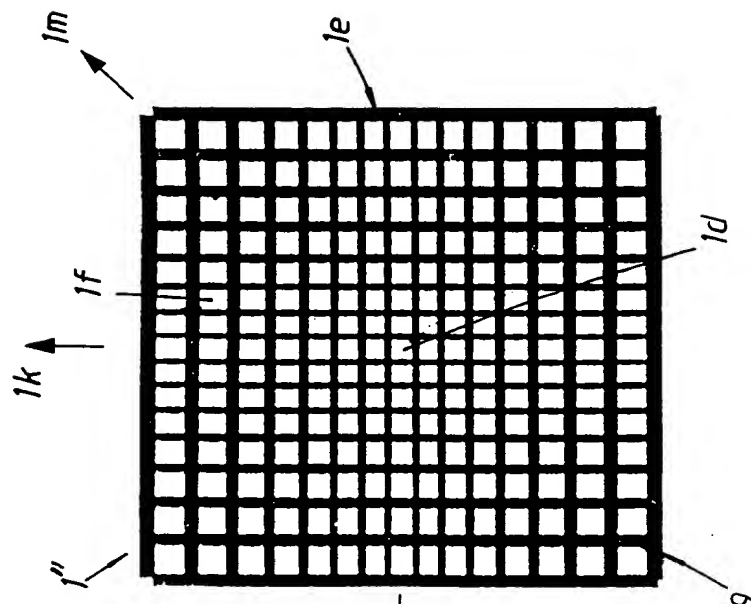


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Fig. 2



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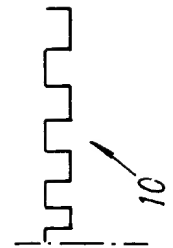


Fig. 5

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Fig. 7

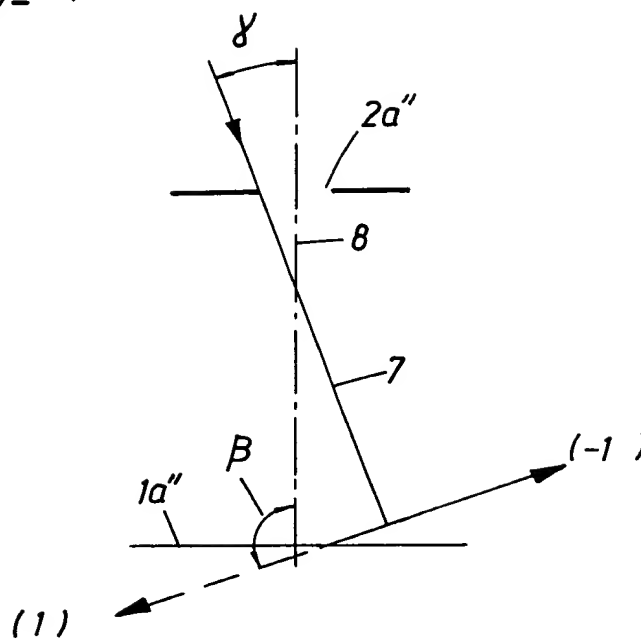
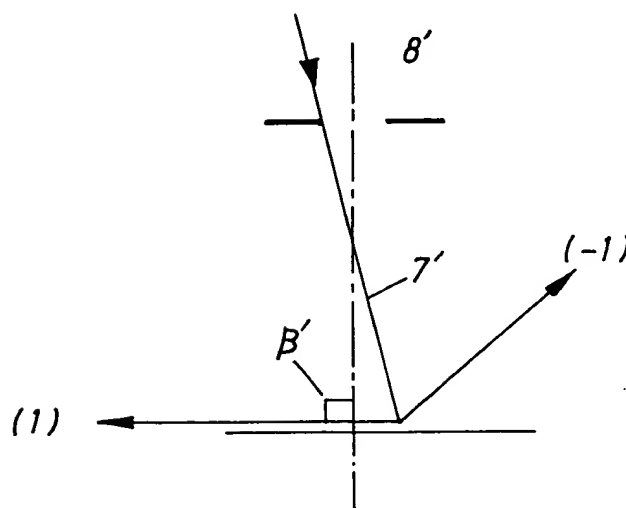


Fig. 8



SUBSTITUTE SHEET

Kvantbrunnsbaserad och tvådimensionell detektor för IR-strålning och kamerasystem med sådan detektor.

5

Föreliggande uppfinning avser en kvantbrunnsbaserad och infraröd strålning avkännande, tvådimensionell detektor som på sin detektoryta mottar infallande infraröd strålning med olika infallsvinklar inom ett område om $0-30^\circ$ i förhållande till ytans normal. Detektorn innefattar ett gitterarrangemang för diffraktion av den infallande strålningen. Uppfinningen avser även ett kamerasystem för infraröd strålning och innefattande optik med bländare och kylvanordning samt en kvantbrunnsbaserad, tvådimensionell detektor som mottar den via bländaren under olika infallsvinklar inom ett område av $0-30^\circ$ i förhållande till detektorytans normal infallande infraröda strålningen. Detektorn innefattar därvid ett gitterarrangemang för diffraktion av den infallande strålningen.

15

Det är känt att utnyttja diffraktionsgitter av olika slag för att höja känsligheten hos en kvantbrunnsbaserade infraröd strålning avkännande detektor, en s.k. QWIP-detektor (Quantum Well Infrared Photodetector). Det kan därvid hänvisas till det svenska patentet 9101034 och de amerikanska patenten 5 075 749 och 5 506 419. QWIP-detektorn i sig är helt okänslig för strålning som infaller vinkelrätt mot ytan, men genom införandet av ett gitter ändras riktningen på den infallande strålningen så att denna kan absorberas i detektorstrukturen. Gittret anpassas normalt så att detektorn blir mest känslig för vinkelrätt mot detektorytan infallande strålning.

25

Det är i och för sig känt att utnyttja dylika detektorer i IR-kamerasystem, i vilka detektorn kombineras med optik och kylvanordning. En viktig komponent härvidlag är den s.k. kalla bländaren, som vanligen är integrerad med detektorn i en vakuumbehållare (dewar). Den kalla bländaren begränsar infallsvinklarna hos strålningen som träffar detektorn.

30

En QWIP-detektor som är försedd med inkopplingsgitter enligt ovan blir normalt känslig inom ett förhållandevis smalt vinkelområde. I synnerhet gäller detta när man utnyttjar gitterarrangemang enligt nämnda svenska patent, där gitterkonstanten eller gitterperioden

är vald så att diffraktionsvinklarna är nära 90° . Det räcker därvid med en mycket liten
ändring av infallsvinkeln för att diffraktionsvinkeln skall bli över 90° i förhållande till
detektorytans normal, varvid den aktuella diffrakterade strålen försvinner som aktiv
komponent i avkänningen, vilket medför att en plötslig minskning av inkopplingsverk-
ningsgraden uppkommer.

För att strålningen skall kunna registreras av detektorn krävs att infallsvinklarna hos
strålningen ligger inom ett vinkelområde där detektorn är känslig. För punkter som
ligger mitt på detektorn, dvs mitt för den kalla bländaren, kommer alla dessa strålar att
ligga inom ett vinkelområde kring 0° , vilket medför att den mesta av denna strålningen
kan registreras. Däremot gäller för punkter i kanten av detektorytan att strålarna infaller
huvudsakligen i sneda vinkar, där förut kända detektorer har dålig känslighet. Detta har
visats i figurerna 1 och 2 där A visar strålningen via den kalla bländaren mot detektor-
ytans mitt och B visar strålningen via den kalla bländaren mot detektorytans ytterkant.
Det föreligger ett behov av att kunna erhålla jämn känslighet över hela detektorytan för
att kunna uppnå bättre bildkvalitet. Uppfinningen avser att lösa bl.a. detta problem.

I anslutning till kamerasystem föreligger även önskemål om att kunna göra optiken
mindre och minska kylbehovet i systemet. Uppfinningen avser att lösa även detta
problem.

Det som huvudsakligen kan anses vara kännetecknande för en detektor enligt uppfin-
ningen är att gitterarrangemanget är valt med en gitterperiod som varierar eller förändrar
sig från detektorns eller detektorytans mittre del och ut mot detektorns respektive detek-
torytans yttre delar eller omkretsdelar. Ett ytterligare kännetecken är att gitterperiodens
variation eller förändring är anordnad för eller bidrar till att i avkänningen bibehålla
diffrakterade strålar av ordningarna 1 och -1 som aktiva komponenter över hela detek-
torytan genom att anpassa de diffrakterade strålarnas vinkelvärden i beroende av infalls-
vinklarna på den infallande strålningen vid detektorytans olika delar.

I utföringsformer av uppfinningstanken föreslås att gitterperioden skall variera linjärt
eller stegvis. I gitterarrangemanget ingående element varierar i gitterarrangemangets
horizontalsnitt sina konfigurationsstorlekar och/eller konfigurationer och är t.ex. kvadra-

tiska vid detektorytans mittre delar och övergår i rektangulära former vid gitterarrangemangets sträckning ut mot detektorytans yttre delar eller omkretsdelar. Ytterligare utföringsformer av uppfinningstanken framgår av efterföljande underkrav till detektoruppbyggnaden.

5

Det som huvudsakligen kan anses vara kännetecknande för ett kamerasystem enligt uppfinningen är att gitterarrangemanget i likhet med ovan är valt med en gitterperiod som varierar eller förändrar sig från detektorns mittre del och ut mot detektorns yttre delar och att gitterperioden eller förändringen är vald att diffraktera strålen som passerar vid bländarens kant, dvs strålen med den största infallsvinkeln, med ett värde intill eller exakt lika med 90° i förhållande till detektorytans normal. Övriga strålar som passerar bländaren kommer då att deffrakteras med mindre vinklar än det förstnämnda värdet, men ändå är nära 90° . Nämnda värden väljes företrädesvis inom området ca $85^\circ - 90^\circ$.

15 Genom det i ovan föreslagna erhålles en utjämnad och mer stabil känslighet utefter hela detektorytan som enligt ovan ger bättre bildkvalitet. I anslutning till det nya kamerasystemet kan detta förfinas ytterligare i förhållande till den kända tekniken.

FIGURFÖRTECKNING

20

En för närvarande föreslagen utföringsform av en detektor och ett kamerasystem enligt uppfinningen skall beskrivas i nedanstående under samtidig hänvisning till bifogade ritningar där

25 figur 1 i principschemaform och från sidan visar genom en bländare mot en detektorytas mitt infallande IR-strålning enligt i och för sig känd teknik,

figur 2 i principschemaform och från sidan visar den via bländaren mot detektorns ytterkant infallande strålningen relaterade till detektorns känslighetsområde, varvid figuren visar fallet för den kända tekniken,

30

figur 3 i horisontalvy underifrån och principiellt visar ett detektorn tillhörande nytt gitterarrangemang i ett första utförande, varvid figuren inte är visad skalenlig,

5 figur 4 i horisontalvy underifrån och principiellt visar ett andra nytt utförande av detektorns gitterarrangemang, varvid figuren ej är visad skalenlig,

figur 5 i diagramform visar linjärt ökande gitterperiod från detektorytans mitt ut mot detektorytans ena ytterkant,

10

figur 6 i diagramform visar gitterperiodens stegvisa ökning eller förändring från detektorytans mitt och ut mot detektorns ena ytterkant,

15

figur 7 i principschemaform visar fallet där diffrakterad stråle går förlorad som aktiv komponent i återgivningen i anslutning till detektorer av känt slag, och

20

figur 8 i principschemaform visar diffrakteringen av den under vinkel via bländaren mot detektorytan infallande infraröda strålningen i enlighet med uppfinningen, varvid strålen mot detektorytans första kant återgivits.

25

Figurerna 1 och 2 är i första hand hänförliga till problematiken som är knuten till förut kända detektorer och kamerasystem. I figuren 1 anges ett strålningsområde A för den infallande infraröda strålningen som träffar detektorn 1, vid dess detektorytas 1a mittre delar 1b. Detektorn 1 kan vara av i och för sig känt slag och det hänvisas härvid till de inledningsvis omnämnda svenska och amerikanska patenten som anger uppbyggnaden på en s.k. QWIP-detektor. En s.k. kall bländare är angiven med 2. Den centralt infallande strålningen är visad med pilar och linjer 3 och 4. Detektorn är huvudsakligen känslig inom ett område som är representerat med en vinkel α . Av figuren framgår att känslighetsområdet (konen) täcker hela bländarens öppning 2a. Den infallande strålningen 3, 4 faller innanför detektorns känslighetsområde 5, 6 i hela sin utsträckning, vilket indikerar en stor känslighetsgrad hos detektorn för den infallande strålningen.

30

I figuren 2 visas att detektorns 1' känslighetsområde vid detektorytans 1a' ytterkant 1c endast delvis är tillgängligt för den under sneda vinklar infallande infraröda strålningen, vars område angivits med β . Endast en mindre del kan således registreras av detektorn, vilket ger lägre känslighetsgrad vid detektorns mottagning av den infallande sneda strålningen. Detektorns känslighetsområde täcker endast en del av den infallande strålningen 3', 4'. Jämför även de streckade linjerna 5', 6' i figuren 2 som visar att detektorns känslighetsområde endast delvis täcker öppningen 2a' på bländaren. I figuren 2 visas dessutom principiellt uppbyggnaden av en IR-kamera K baserad på QWIP-detektor 1'. I kameran ingår en optik O och en kylvanhet KE. Nämnade komponenter är i och för sig kända och på i och för sig känt sätt inbyggda i en kamerastomme KS. I figuren 2 är bländarens diameter angiven med D och avståndet mellan bländare och detektorns ovan- yta 1a' med S.

I enlighet med uppfinningen skall gitterstrukturen anpassas efter infallsvinkeln hos den infallande strålningen. Detta innebär företrädesvis att gitterperioden blir längre i kanten av detektor än i mitten. Gittret är företrädesvis tvådimensionellt för att vara okänsligt för strålningens polarisation. I figuren 3 är ett gitterarrangemang visat från ifrågakarande detektors undersida. Detektor är i princip angiven med 1''. Gitterelementen är i utföringsexemplet utformade med fyrkantsformade konfigurationer. Vid gitterarrangemanget eller detektorns mittre delar 1d är gitterelementen väsentligen kvadratiske, medan de vid detektorns ytterkant 1e är väsentligen rektangelformade. Ett gitterelement är i figuren 3 angivet med 1f. Figuren är ej visad skalenlig, utan utgör endast en principskiss.

I enlighet med en första utföringsform av uppfinningstanken varierar gitterperioden linjärt från detektorns mitt 1d ut mot detektorns ytterkant 1e.

Nämnda variation eller förändring av gitterperioden kan i enlighet med figuren 4 anordnas stegformigt och ökande ut från detektorns mittre del 1d' till detektorns ytterkant 1e'. I utföringsexemplet enligt figuren 4 är den stegvisa ökningen i gitterarrangemanget anordnat med hjälp av bandliknande formationer 1g och 1h som i princip korsar varandra vid detektorns mittre delar 1d'. På så sätt erhålles i området som täckes av både bandet 1g och 1h en första täthet i gitterarrangemanget. I delar som var för sig täckes av de bandformade arrangemangen 1g och 1h erhålles en andra täthet i gitterarrangemanget. I

hörnerna av gitterarrangemangen som är symboliserade med l_i erhålles en tredje täthet för gitterarrangemanget. Hörnen l_i korsas inte av de bandformade strukturerna l_g och l_h . Gitterperioden är mindre vid de mittre delarna och ökar utåt mot de yttre delarna.

- 5 Gitterarrangemangen kan sprida sig från detektorytans mittre delar ut mot detektorytans yttre kanter med ökande gitterperiod eller steg i princip alla riktningar som i figur 1 är indikerade med l_k , l_l , l_m respektive l_k' , l_l' , l_m' .

10 Figuren 5 är avsedd att visa den linjärt ökande gitterperioden i gitterarrangemanget räknat från detektorns l'' mittre del l_d vinkel ut mot dess raka ytterkant l_e . På motsvarande sätt avser figuren 6 att visa den stegvist ökande gitterperioden från detektorns l''' mitt l_d' vinkelrätt ut mot ytterkanten l_e' i figuren 4.

15 Figuren 7 avser att visa fallet vid den tidigare kända tekniken. I detta fall är bländaren principiellt angiven med $2a''$ och den infallande strålen med den största vinkeln mot detektorns ovanyta $1a''$ med 7. Figuren 7 avser att visa att diffrakterad stråle av ordningen (1) har erhållit en vinkel β i förhållande till ytans normal 8 som är större än 90° . Detta innebär att ifrågavarande stråle går förlorad som aktiv komponent i avkänningen eller registreringen. I figuren 7 är en vinkel χ angiven mellan den infallande strålningen och ytans normal 8. Sistnämnda maxvinkel väljes företrädesvis inom området $0-45^\circ$.

20

I figuren 8 visas förbättringen enligt uppfinningen. Den infallande strålningen $7'$ som motsvarar den infallande strålningen 7 enligt figuren 7 diffrakteras med diffraktionsstrålarna av ordningarna 1 och -1 enligt figuren. Genom lämpligt val av gitterperiod kommer diffraktionsstrålen av ordningen 1 att anta ett värde β' som är 90° eller mycket nära 90° , vilket medför att strålen ifråga kan bibehållas som aktiv komponent, vilket ger upphov till att känsligheten hos detektorn ökar.

25

I en föredragen utföringsform väljs gitterperiodens variation utefter detektorytan i enlighet med följande. Utgångspunkten är därvid en given bländardiameter D (se figuren 2) på avståndet S (se figuren 2) från detektorns yta $1a'$. En gitterperiod $d(x)$ för en punkt på avståndet x (se figuren 2) från detektorns mitt l_d (se figuren 3) väljes på så sätt att den stråle som har största infallsvinkeln diffrakteras i precis 90° i förhållande till normalen.

30

Denna stråle passerar precis kanten av bländaren. Alla andra strålar som släppes igenom har mindre infallsvinkel och diffrakteras därför i vinklar mindre än, men nära 90° (se ovan). Matematiskt uttryckt blir gitterperioden:

$$5 \quad d(x) = \frac{\lambda}{n - \sin \alpha_{0\max}(x)}$$

där λ är våglängden, n är gittersubstratets brytningsindex och $\alpha_{0\max}(x)$ är maximala infallsvinkeln och ges av formeln:

10

$$\tan \alpha_{0\max}(x) = \frac{x + D/2}{S}$$

I en annan föredragen utföringsform väljs gitterperioden enligt en förenklad metod, härledd ur ovan beskriven metod, genom att approximera $\sin \alpha_{0\max}$ och $\tan \alpha_{0\max}$ med $\alpha_{0\max}$.

15 Då ges gitterperioden av

$$d(x) = \frac{\lambda}{n} \left(1 + \frac{D}{2nS} + \frac{x}{nS} \right)$$

det vill säga, gitterperioden varierar linjärt från mitten ut till kanten.

20

I ett utföringsexempel väljes därvid värdena $\lambda = 9 \mu\text{m}$, $D = 7 \text{ mm}$ och $S = 14 \text{ mm}$. För substratet eller materialet GaAs är $n = 3,28$. Vid detektorns mitt erhålles $d = 2,95$. Vid kanten, t.ex. 8 mm från mitten blir $d = 3,43 \mu\text{m}$. I ett utföringsexempel väljes d vid detektorns mitt inom ett område 2,5 – 3,0 μm och vid detektorns ytterkant inom ett område 3,0 – 3,5 μm , varvid de högre värdena är relaterade till varandra inom de båda områdena, liksom de lägre värdena.

25

Val av gitterperioden d för värden för β' lika med eller nära 90° erhålles medelst

$$30 \quad \frac{\sin \alpha_0}{n} + \sin \beta_m = \frac{m\lambda}{nd}$$

Det i ovan omnämnda gitterarrangemanget har erhållit beteckningen 9 i figuren 3 och en kurva för periodiciteten enligt figuren 3 har i figuren 5 erhållit beteckningen 10, medan periodiciteten enligt figuren 4 har erhållit beteckningen 11 i figuren 6.

- 5 Uppfinningen är inte begränsad till den i ovan såsom exempel visade utföringsformen utan kan underkastas modifikationer inom ramen för efterföljande patentkrav och uppfinningstanken.

PATENTKRAV

1. Kvantbrunnsbaserad och infraröd strålning (3, 4) avkännande, tvådimensio-
5 nell detektor (1) som på sin detektoryta (1a) mottar infallande infraröd strålning med
olika infallsvinklar, företrädesvis inom ett område $0-45^\circ$, i förhållande till ytans normal
(8) samt innefattande ett gitterarrangemang (1f) för diffraktion av den infallande strål-
ningen, k ä n n e t e c k n a d därav, att gitterarrangemanget är valt med en gitterperiod
som varierar eller förändrar sig från detektorns mittre del (1d) och ut mot detektorns yttre
10 delar (1e) eller omkretsdelar, och att gitterperiodens variation eller förändring är anordnad
eller bidrar till att i avkänningen bibehålla diffrakterade strålar av ordningarna 1 och -1 som
aktiva komponenter över hela detektorytan genom att anpassa de diffrakterade strålarnas
vinkelvärden i beroende av infallsvinklarna (α) på den infallande strålningen vid detektor-
ytans olika delar.
- 15
2. Detektor enligt patentkravet 1, k ä n n e t e c k n a d därav, att gitterperioden
varierar linjärt.
3. Detektor enligt patentkravet 1, k ä n n e t e c k n a d därav, att gitterperioden
20 varierar stegvis.
4. Detektor enligt patentkravet 1, 2 eller 3, k ä n n e t e c k n a d därav att i gitter-
arrangemanget (9) ingående element (1f) i gitterarrangemangets horisontalsnitt varierar sina
konfigurationsstorlekar och/eller konfigurationer och t.ex. är kvadratiska vid detektorytans
25 mittre del (1d) och övergår i rektangulära former vid gitterarrangemangets (9) sträckning ut
mot detektorytans yttre delar (1e) eller omkretsdelar.
5. Detektor enligt något av föregående patentkrav, k ä n n e t e c k n a d därav, att
gitterarrangemangets period (10, 11) är vald så att detektorns avkänning eller känslighet blir
30 väsentligen densamma över detektorns hela yta (1a).

6. Detektor enligt något av föregående patentkrav, k ä n n e t e c k n a d därav, att gitterperioden ökar med avståndet från detektorns mittre delar ut mot dess yttre delar eller omkretsdelar (1e).

5

7. Detektor enligt patentkravet 1 eller något av patentkraven 2-6, k ä n n e t e c k n a d därav, att gitterperioden varierar enligt

$$d(x) = \frac{\lambda}{n - \sin \alpha_{0\max}(x)}$$

10

där λ är våglängden, n är gittersubstratets brytningsindex och $\alpha_{0\max}(x)$ är maximala infallsvinkeln och ges av formeln

$$\tan \alpha_{0\max}(x) = \frac{x + D/2}{S}$$

15

8. Detektor enligt patentkravet 7, k ä n n e t e c k n a d därav, att gitterperioden är vald med hjälp av approximation av $\alpha_{0\max}$ och $\tan \alpha_{0\max}$ med $\alpha_{0\max}$, varvid gitterperioden framgår av

$$d(x) = \frac{\lambda}{n} \left(1 + \frac{D}{2nS} + \frac{x}{nS} \right),$$

20

dvs gitterperioden varierar linjärt från mitten ut till kanten.

9. Detektor enligt patentkravet 1 eller något av patentkraven 2-7, k ä n n e t e c k n a d därav, att gitterperioden uppvisar värden av ca 2,5-3,0 mikrometer vid detektorns mitt och ca 3,0-3,5 mikrometer vid detektorns yttre delar, varvid de högre värdena inom de båda områdena är hänförliga till varandra och de lägre värdena inom de båda områdena är hänförliga till varandra.

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10. Kamerasystem för infraröd strålning och innefattande optik (O) med bländare (2) och kylvanhet (KE) samt en kvantbrunnsbaserad, tvådimensionell detektor (1) som mottar den via bländaren under olika infallsvinklar (α), företrädesvis inom ett område av 0-45°, i förhållande till detektorytans normal (8) infallande infraröda strålningen (3, 4), varvid detektorn innefattar ett gitterarrangemang för diffraktering av den infallande strålningen, k ä n n e t e c k n a d därav, att gitterarrangemanget är valt med en gitterperiod

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som varierar eller förändrar sig från detektorns mittre del och ut mot detektorns yttre delar, och att gitterperioden eller förändringen är vald att diffraktera strålen ($7''$) som passerar vid bländarens ($2a''$) kant, dvs strålen med den största infallsvinkeln, med ett värde intill eller exakt lika med 90° och att diffraktera strålar med mindre infallsvinklar med värden som understiger det förstnämnda värdet, men ändå är nära 90° , vilka värden företrädesvis är valda inom området $85^\circ - 90^\circ$.

SAMMANDRAG

En kvantbrunnsbaserad och infraröd strålning avkännande tvådimensionell detektor (1)
5 mottar på sin detektoryta (1a) infallande infraröd strålning med olika infallsvinklar.
Detektorn innefattar ett gitterarrangemang för diffraktering av den infallande strålningen.
Arrangemanget är valt med en gitterperiod som varierar eller förändrar sig från detek-
tors mittre del och ut mot detektorns yttre delar. Gitterperiodens variation eller föränd-
ring är anordnad att i avkänningen bibehålla diffrakterade strålar av ordningarna 1 och -
10 1 som aktiva komponenter över hela detektorytan genom att anpassa de diffrakterade
strålarnas vinkelvärden i beroende av infallsvinklarna på den infallande strålningen vid
detektorytans olika delar.